HORSE, TRUCK, AND TRACTOR

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Power and the Plow
Traction Plowing (Government Report)

Illustration of the use of a motor-truck in contracting engineering work. This particular truck, according to its owners, did the work of 10 two-horse teams in hauling sack cement to be used in the construction of the great Catskill Aqueduct, New York City

Plowing a 15-acre corn-belt field

HORSE, TRUCK, AND TRACTOR

THE COMING OF CHEAPER POWER FOR CITY AND FARM

BY

HERBERT N. CASSON

Author of "The Romance of the Reaper," "Ads and Sales," etc.

ROLLIN W. HUTCHINSON, JR.

Author of "Electricity in Mining," etc.

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INTRODUCTION

WHEN the "World's Work" Magazine wanted a series of articles on the subject of motor-trucks, it made an investigation and selected as the most efficient expert Mr. Rollin W. Hutchinson, Jr.

When the Department of Agriculture wanted an authoritative report on the subject of farm tractors, it selected as the most efficient expert, Mr. L. W. Ellis.

Therefore, we may fairly assume that both Mr. Hutchinson and Mr. Ellis are the leading authorities on this timely topic of HORSE, TRUCK, AND TRACTOR.

Fortunately, both gentlemen are also writers of unusual ability, as well as experts; and we can expect this book to be as interesting as it is valuable and important.

No other subject, I believe, is more timely than this; and no other writers are as competent to put us on the road to a practical solution of the problem of cheaper power for city and farm.

HERBERT N. CASSON

New York, *January, 1913*

CONTENTS

ILLUSTRATIONS

)RSE, TRUCK, AND TRACTOR

CHAPTER I

THE HORSE-COST OF LIVING

HORSE. ENTER TRUCK AND TRACTOR

IERE you have, in six words, a definition of the Power Revolution that is now taking place in the cities and on the farms of the States.

horse has become unprofitable. He is too buy and too costly to keep. His price has 1 143 per cent in the last ten years.

:ost of his feed, his harness, his barn, his hos- ve all increased. Nothing that concerns the s remained the same except his power. He is pound stronger today than he was thirty years he days of his cheapness.

annual Horse-Cost has grown until it is now our Railroad Cost. Our 25,000,000 horses les consumed food last year to the value of)0,000, or as much as the total operating cost

of all the 250,000 miles of railroad in the United States.

Men work more for horses than horses work for men — such is the conclusion we reach after reading the latest data on horse-chores and horse-feed and horse-cost.

A Government report announces that the one trifling item of horse-chores requires 27 minutes a day per horse. This is equal to 20 days a year per horse, allowing an 8-hour day.

The drudgery of horse-chores is a sort of labor that can never be improved. It is dirty, disagreeable work, not in any degree like the skilled work of a mechanic or chauffeur or tractioneer. It is personal service rendered to lower animals by men.

More degrading still, is the work performed by thousands of street-cleaners, who would be unnecessary in horseless cities. All these men would be more content and more useful if they were engaged in cleaning trucks and tractors and automobiles.

Also, among the human servants of the horse, we must count the harness-makers, the tanners, the buckle-makers, and whip-makers. We must count the stable-builders and the men who make the raw materials of stables.

We must count the veterinary surgeons and the blacksmiths. Merely the horse shoes that were

hammered on by last year's blacksmiths contained enough iron to make 40,000 tractors.

We must count the hay-makers and hay-balers and all the men who handled, last year, 73,000,000 tons of hay. If they had devoted the same time and the same land to the raising of wheat and potatoes and corn, they would have had enough extra food to supply the cities of New York, Philadelphia, and Chicago.

We must count the makers and retailers of horse-feed, and the makers of horse-feed machinery — mowers, rakers, tedders, feed-grinders, etc. Add to these the makers of raw materials and the railway men who supply transportation, and the total number of horse-valets will be amazing.

As Edison has said, a horse is the poorest motor ever built. He eats 10 pounds of food for every hour he works. He eats 12,000 pounds of food a year. He eats the whole output of five acres. And yet his thermal efficiency is only TWO per cent.

As a recent Government report shows, a farm horse averages 3½ hours of work a day. He tires out in six hours; so that we may fairly assume a tractor to be as powerful as 25 horses, as enduring as 100 horses; and about as expensive as ten.

A horse is cumbrous, too, as well as inefficient. He requires 750 cubic feet of barn. He and his feed require

3250 cubic feet. All told, our horses and mules consume in a year 73,000,000 tons of hay — an immense bulk which has to be produced and handled. If all the horse-food were grown in one vast farm, that farm would be as large as Iowa, Indiana, Illinois, and Ohio combined.

If horses were as prolific as rabbits or guinea-pigs, we might possibly struggle through with horse-power. But the fact is that horses have well known race suicide tendencies; and even when a colt is born, he requires four years to develop into a work-horse.

During 1912, in Kansas, more than 20,000 horses died of a new mysterious disease, which was commonly called the "horse-plague." How can these horses be replaced by others? There is no surplus of horses in any State; and four years must elapse before 20,000 new horses can be developed.

In Western Canada we find this shortage of horses most conspicuous. To plow the 200,000,000 new acres of Western Canada requires the power of 4,000,000 horses — twice as many horses as there are in the whole Dominion of Canada. There is absolutely no way, therefore, for this new vast region to develop itself, except by the use of tractors.

The horse has been left behind in the development of industry and agriculture. In the days of the spade and the sickle he was big enough; but today he is

dwarfed by the 5-ton steam-shovel and the automatic harvester.

This is the day of BIG UNITS. One freight-car carries 80,000 lbs. One Erie canal-boat carries 100,000 bushels of wheat. One grain-ship on the Great Lakes carries 250,000 bushels. One train carries the grain that was grown on 6000 acres. One grain elevator holds 6,000,000 bushels. One flour-mill at Minneapolis fills 17,000 barrels with flour in a single 24-hour day.

One single steel girder in the Woolworth Building was so heavy that sixteen horses were required to haul it from the freight-yard. One single copper mine — the Red Jacket, has engines of 8000 horse-power, which hoist 10-ton cars of ore to the surface of the ground in 90 seconds, from 5000 feet below. One single iron ore steamer — the *Augustus B. Wolvin*, loads 10,000 tons in 89 minutes and unloads in four hours. One single passenger steamship — the *Lusitania* or *Mauretania*, hurls herself through the waters of the Atlantic with the power of 70,000 horses.

This is the day of TONNAGE. The average American iron and steel plant, in 1870, produced 4039 tons; today it produces 57,500 tons. The output of Pittsburgh alone is equal, in tonnage, to a Great Pyramid every four weeks. It means, in just a single year, 35,000 trains of cars, 50 cars to a train, 50 tons to a car. Ninety million tons a year! All the horses and mules

in the United States could not budge the annual tonnage of Pittsburgh.

One single American company — the United States Steel Corporation — smelts in one year 25,000,000 tons of iron ore; and it handles this stupendous output from ore-bed to finished product without the use of horses. If the iron and steel business were on a horse-power basis, steel rails would not be $28 a ton — less than one and a half cents per pound.

Talk about tonnage! So vast have our industrial enterprises become, that the total freight now carried, by rail and ship, is fully 2,000,000,000 tons a year.

Both human muscle and horse muscle are too weak for the heavy labors of today. Both men and horses are too feeble and too slow for this age of Speed and Tonnage.

For instance, a man can throw a 56 pound shot 23 feet and no more. That is the world's record. But we have cannon that can throw a 56 pound shot 23 miles.

The fastest swimmer goes 2 miles an hour. The fastest walker goes 5 miles an hour. The fastest sprinter goes 20 miles an hour. The fastest long distance runner ran 100 miles in 13 hours, 26½ minutes. The fastest skater went 100 miles in 17 hours, 11 minutes, and 38 seconds. The fastest dog team went 412 miles in 82 hours. The fastest long distance ride on

horseback was 200 miles in 8 hours; and the fastest trotter covered a mile in 1 minute, 58½ seconds.

As against these records of speed made by muscle, compare the speed of that trolley car at Zossen, which flew over the rails at the rate of 132 miles an hour.

An average man can shovel 20 pounds at a lift and carry 50 pounds on his back, whereas a steam-shovel moves 10,000 pounds at a lift, and a motor truck can carry 10 tons.

The average horse-wagon or horse-truck in farm and city is too small. It is no bigger than a pushcart when we compare it with the other large machines that are in daily use. A single steam-shovel in the Mesaba Range picks up enough in a single load to fill three or four wagons. A single freight-car holds from 25 to 30 wagon loads. Consequently, much time is lost by the use of these small wagons, just as it used to be lost by the use of wheelbarrows and spades.

We have come into an age of heavy loads and large operations. There is no comparison between the buildings of today and the buildings of fifty years ago. Yet the streets of every American city and the roads through every county are still dotted with tiny wagons that are no larger than the wagons of log-cabin days.

It has been estimated that the total cost of hauling wheat to market — from farm to railroad station — is more than $35,000,000. The total cost of hauling

all farm products from farm to town is $130,000,000. We must add to this the cost of hauling from the railroad to the flour-mill, the commission merchant, the retailer, and the consumer. The nearer we get to the consumer, the smaller is the load and the heavier is the cost.

The big way is the cheapest. Compare, for instance, the cost of traveling in a street car with the cost of traveling in a cab.

In a cab, which originally cost, horse and all, not more than $1000, the average fare is $1.50; yet, in a street car, which cost $10,000, the average fare is 5 cents.

Cab service is thirty times dearer than street car service because a cab is so small—because it is made for one person only.

We find the same result when we compare the cost of the tractor with the cost of the horse. With a team of horses, costing $500, one man can plow 100 acres at a cost of $250; yet, with a tractor costing $3000, one man can plow 100 acres at a cost of $150. Here is a saving of $1 an acre in plowing alone, which means very nearly a million dollars a day saved in the cost of plowing American farms.

In all the civilized countries in the world, factory work has been found to be cheaper than hand labor. There is nothing that cuts down costs like power and machinery. Manufacturers found this out several

generations ago, and the horse owners of today are gradually finding it to be true.

It is not first cost that counts. It is MAINTENANCE and OUTPUT. The interest cost of a \$3000 tractor, for example, is only \$4.00 a week. This is less than half the cost of the cheapest laborer.

Until the coming of the Tractor, the plow was the slowest of all farm machinery. It was the snail of the farm. It turned only one furrow at a time and it moved at a rate of 2½ miles an hour. A cablegram can be sent completely around the world while a horse-plow is moving 200 yards.

Every five square miles of plowing with a horse-plow means a distance traveled of 25,000 miles. It means a single furrow around the whole earth. Merely to plow enough land for one loaf of bread requires a single furrow fifty feet long.

But with a Tractor, the single furrow becomes a thing of the past. We are enabled to turn TWELVE or more furrows at once. This is equal to a single plow moving at the rate of thirty miles an hour. This is HIGH-SPEED PLOWING—the latest great achievement on the road to cheap production.

FARMING A LA FACTORY — this is the keynote of the New Agriculture. There is today on American farms an equipment of labor-saving machinery that cost \$1,300,000,000. For every dollar invested in horses

and mules, there is now nearly half a dollar invested in farm machinery.

More than 2,500,000 horse-power of mechanical power is now on our farms. The average farm in Ohio has an $1100 equipment of labor-saving machinery. This is high compared with the average farm; but it is low compared with the efficient profit-making farms of the future.

Fully five-sixths of our farm work is now being done by machinery. That is why we produce one-fifth of the wheat, one-half of the cotton, and three-quarters of the corn of the world, although we are only six per cent. of the human race, and only three-fifths of us on farms.

Talk about the high cost of living! If it were not for farm machinery we could not live at all. Our cities would shrivel up from forty per cent. of our population to three or four per cent., as they were in the pre-machinery days.

A hundred years ago four farmers could just barely raise enough wheat to feed themselves and one other family; but today North Dakota alone grows wheat enough to feed herself and 12,000,000 people besides. Such is the increment of machinery.

No farm can be run today at a profit with hand-labor tools. No banker would lend money on a farm where the grain is being cut with hand-sickles and threshed

flails. It is the machinery, combined with
fic methods and large units of production, from
farm profits are now being derived. Small
·s, with small and old-fashioned operations, are
g no profits at all.

matter whether you live in the Red River Valley
he Waldorf-Astoria, this matter of cheaper power
ns you and your family.

aper power means cheaper bread, meat, fruit,
bles, sugar, rice, cotton, linen, leather. It means
:rops — more manufacturing — more prosperity.
er power is everybody's business.

h the exception, perhaps, of jewelry, lace, and other
ɔdities that are exceptionally light and costly,
goods that we buy are taxed to support the horse.
ax, on our total domestic commerce, is not far
› per cent. It is one of the heaviest and most
sal indirect taxes that we are compelled to pay.

as the operating of slave plantations became
itable in 1850, because of the increased cost of
nd slaves, so the operating of horse-power farms
:orporations has become unprofitable today.
ɔw we are in a transition period. We can neither
ΓH horses nor WITHOUT them; but the steady
re of events is forcing us away from our horse-
point of view and compelling us to take notice of
and tractors.

The horse, like the buffalo, has had his day. He is even now being displaced by the engined vehicle, just as the stage-coach was displaced by the railroad, the tinder box by matches, the canoe by the steamship, the puddling furnace by the Bessemer converter, the log cabin by the skyscraper, the ox cart by the auto, the sickle by the self-binder, the flail by the threshing machine, the pen by the Hoe press, and the needle by the sewing machine.

The horse is today an unprofitable servant. We are using him mainly for two reasons —

1. Because we are not yet quite ready for the new machines which have been invented to take his place.
2. Because we still have the horse habit; our brains are accustomed to think in terms of horse-power and to cling to the horse idea.

Nothing is more difficult than to move the mind to a new habit of thought. The United States has grown up with horses. It is accustomed to horse-plows and horse-wagons. It has learned to look upon the horse as an absolutely indispensable helper, both in the city and on the farm. In short, the horse-owner has horse in his brain; and it is, therefore, a slow and difficult matter to move him from the horse habit to the engine habit.

McCormick invented his first reaper in 1831, but at that time the farmers of the United States were not

ready for reapers. They had sickles in their minds. They could not imagine the cutting of grain by anything else than human muscle. The very idea of "cutting grain by horses" was laughed at for years as a most absurd and preposterous joke.

McCormick fought against the sickle idea for fourteen years before he sold his first hundred reapers. Then came the Gold Rush to California in 1849. Tens of thousands of laborers became gold seekers, so that there was a dearth of labor in the harvest fields. The farmers were compelled to buy reapers. They had to choose between buying reapers and letting their wheat rot in the fields.

In the same way, horse-owners are today being compelled to use trucks and tractors. No matter what objections they may have in their minds, there is nothing else to do. The present situation cannot be handled with horses; and it *can* be handled with machinery.

No other invention of man has been so useful as the wheel that drives itself. Merely the wheel, without the engine, was a great achievement. A wheel is vastly superior to legs, from the point of view of efficiency.

A wheel, we may say, is a circular leg with a perpetual foot. Nature did not give us wheels. It gave Man nothing but two spokes, without a rim; and it gave the horse four spokes, without rims.

Whoever first invented wheels was a genius. He was equal to Caxton or Copernicus or Columbus. He gave us the best labor-saving device that was ever conceived in the human brain.

But for thousands of years the wheel had to be pulled by legs — the legs of some man or some animal. This was a great disadvantage, and it was not overcome until the invention of the steam-engine. Since James Watt, wheels have been able to push themselves; and during the last ten years, the gas engine has been developed into the handiest and cheapest of all wheel-pushers.

We have solved the long-haul problem, but not the short-haul problem. For instance, one wheat ship today carries a ton 13 miles for 1 cent; whereas the average cost of hauling grain to market in horse-wagons is 9 cents per 100 pounds. It costs more to carry wheat 10 miles by horse and wagon than 2300 miles by steamship. You can pick up a bushel of wheat in St. Louis and send it to Liverpool for 10 cents — such is the efficiency of long-haul transportation.

The solution of this problem of short-haul efficiency is not more teaming. It is not a matter of more horses, more hostlers, and more wagons. It is a matter of invention and engineering; and the answer is here now for all horse-owners of enterprise and foresight.

It is the same answer that solved the problems of

manufacturing and building and rapid transit. It is the displacing of muscle by machinery.

The horse, after all, is an optical delusion, so far as power is concerned. He is not as strong as he looks. Practically all of his pulling is done with one hind leg. His front legs are pilot legs mainly, like the pilot wheels of a locomotive. They serve more to hold up the weight of the body than to pull the load.

If a horse were made of steel, like a gas engine, he would, in fact, be no larger than a waste-basket or a soap-box. Being a hay motor, he had to be made enormously large in proportion to his power.

This fact about the horse, that he burns hay for fuel, makes him enormously expensive. No other engine costs as much per horse-power as horses do at present. Our latest and largest electric engines of 4000 horse-power cost only $60,000, or $15 per horse-power. This is a remarkable cheapening over the tiny Peter Cooper locomotive of 80 years ago, which was 2 horse-power, and cost $2000 — $1000 per horse-power.

When land was $20 an acre, and when horses were $50 apiece, there was no urgent need for engines, either in a city or on a farm. But today we have an entirely different situation. Land, ordinary farm land, has gone up in price until it touches $200 an acre. Horses, ordinary horses, without a pedigree, have gone up in price until $1000 will only buy three or four of them.

Land has gone up in price, and partly in quality, through the development of scientific agriculture. Horses have gone up in price and not in quality. Engines, on the other hand, have gone up in quality and away down in price. They were never so strong and so cheap as they are today.

This being the case, there can only be one end to the whole matter. The laws of business are as inevitable as the laws of nature. *Business swings towards lowest costs*, as inevitably as the waters fall over the cliff of Niagara. No matter what our theories may be, and no matter what our wishes may be, the horse is going out and the engine is coming in, because the engine is the fittest to survive.

This picture shows the application of a motor-truck in "squadron" fashion. Fifteen of these 5-ton trucks are used by the City Fuel Company of Chicago for coal delivery in the loop district of Chicago

Up-to-date method of loading motor-trucks for heavy coal delivery in New York

CHAPTER II

MOTOR TRUCKS — THE NEW FREIGHTERS

A HORSELESS city and therefore a city of clean streets, a city in which the heavy traffic takes less space on the street and also moves more quickly than it does now, a city with a good delivery service to all the territory within twenty-five miles — such are the conditions which the motor-truck builders believe in.

The passenger automobile has been condemned as an incentive to luxury, praised as an influence for good roads, and lauded for helping the farmer out of his isolation and for taking many city people to the country. But in the last few years another kind of automobile — the motor truck — has become a large part of the industry. In 1910 the sales of pleasure cars (including many of course used for productive service of various kinds) amounted to $307,000,000. By the beginning of 1913, $125,000,000 worth of business vehicles had been sold since the inception of the industry. These fifty thousand trucks mean usefulness and increased efficiency. There is no criticism of

luxury against these cars, and they, as well as the pleasure cars, argue for good roads, and have made it easier for men and for businesses to move to the country.

The motor truck bases its claim purely on utilitarian grounds — that it gives better service than horse-drawn vehicles or that it does work cheaper, or both; that it is increasing efficiency.

One of its chief advantages over the horse and wagon is in the greater territory which it can cover. A single horse with a one-ton wagon, for instance, has a very restricted radius of action, averaging twenty-two miles a day — and to attain this, one-half the distance is generally covered without load. In other words it has a productive mileage of eleven miles for a day's service. The two-horse, three-ton wagon will average twenty miles a day, or a productive service of ten loaded miles. The three-horse, five-ton wagon, which is the largest practical unit for city service, is limited to a working radius of eighteen miles a day, or nine miles with load. It is interesting to compare the daily average mileage of power vehicles of equal and larger load capacities with these figures. A first-class, one-ton power truck is easily capable of traveling eighty miles a day. The three-ton truck can cover sixty miles, and, if well built, is capable of repeating the performance six days a week without material yearly depreciation. A good five-ton truck will average fifty

miles a day while a ten-ton truck can make thirty-eight miles.

While the ordinary horse and wagon is going four miles in an hour, the one-ton truck will cover eighteen miles. It can make a delivery ten miles from the store very nearly two hours quicker than the wagon. Where time is money in delivery, such a saving is most important. Even a five-ton truck, which is the largest size needed in most businesses, can go ten miles in an hour, or about three times as fast as a three-horse wagon's speed. Besides its greater speed the motor truck has the added advantage of being able to work all day and every day in rush periods without rest. It can run night and day continuously when need be. It costs much less to store than idle horses; it takes less room. A garage 35×60 feet will hold five heavy trucks. Thirty-five or forty horses and eight or ten wagons would need three or four times this space. Moreover bad weather affects motor truck deliveries very little.

With the coming of deep snows and glassy pavements the limitations of the horse are forcibly impressed on the minds of every urban dweller. The efforts of horses to stay on their feet in drayage service in our Northern cities, much less to pull heavy loads, is so exhausting and so laming that their efficiency is badly impaired and the reliability of delivery of mer-

chandise by animal power is reduced. The power vehicle, on the other hand, has only to attach chains or some other form of anti-skidding appliance to the tires and go on as well as ever. The use of the power vehicle in winter does necessitate, however, a certain degree of care by the driver to obviate freezing of the radiator of a water-cooled gasolene machine; but with ordinary care this disadvantage of the internal combustion motor is a negligible factor.

The thorough reliability of the gasolene motor business truck in the winter season was forcibly demonstrated in an extraordinary performance with a three-ton truck last winter. A large motor-cycle manufacturer in Massachusetts had an important shipment for exhibition at a London show to forward to New York, and it was necessary to get it on a certain steamer or be debarred from showing his product abroad. The heavy snows had congested freight traffic so badly that the railways could not promise a car in time to catch the steamer. In despair the motor-cycle maker appealed to a power-truck builder to get the shipment to New York within the time limit — three days. Although the roads were badly blockaded with snow and ice the power truck made the journey, one hundred and fifty miles, to New York in less than two days, and the shipment went on its way to Europe.

But to an even greater degree does the boiling heat of summer demonstrate the superior efficiency of power business vehicles over horses in the actual service performed. When the heat brings down the normal efficiency of draught horses, causing sickness and heavy mortality — delays in delivery and the spoiling of perishable products cost the public hundreds of thousands of dollars. Those who are disposed to weigh with overnice discrimination the last dollar and cent of trucking expense, who see in the power business vehicle nothing but "How much can I save?" or "How much will it cost me?" are gradually being forced to face the issue on its rightful basis and to appreciate that service and not saving alone is the true standard of value of the power wagon (but saving is usually a concomitant of service). The power vehicle will give just as good service on the hottest summer day as in ordinary times and moreover, will perform work which no animal team can possibly do.

The extraordinarily warm weather of the early part of July, 1911, was a striking object-lesson to the owners of horse-drawn vehicles. In New York City, which has the largest number of horse teams (as well as power trucks) in service, there are normally 140,000 horses hauling loads. In ten days, commencing with the excessive heat period of July 3, the Society for the Prevention of Cruelty to Animals reported that one

thousand two hundred of these horses dropped dead in harness, or a ratio of nearly one in a hundred. In addition to this heavy mortality, which is nearly double the ordinary death-rate, thousands of animals were wind-broken or ruined for hard service.

A New York wholesale grocer who formerly had seen only the monetary side of machine delivery, very ably and forcefully sums up his opinion of the advantages of power vehicles in the summer season:

"I will never again say a word about what my trucks cost after having seen them go right ahead in this boiling weather, just as they do in ordinary times. We have a lot of trade down at Coney Island which we formerly tried to hold with horse-drawn vehicles, but it would be cruelty to horses to expect them to attend to it in weather like the past week; in fact, all we could expect would be one trip a day, and if we had made that this week our horses would have had to lay off the next day. As a matter of prudence, I wouldn't dare to send horses down there, and, when cost is considered, it would have been almost prohibitive to use a pair of horses all day for that one trip. But our little two-ton truck has been making three trips a day easily without trouble.

"On some of the stuff we have been taking down we formerly had to ice the goods to prevent spoilage on the trip. It meant paying high prices for ice at a

time when there was mighty little ice to be had, and adding that much more weight to the load, and by the end of the trip the ice would be gone. Now we merely cover the stuff over with wet burlap and it arrives at the Island hardly any warmer than at the start. I understand that the marketmen who use trucks have found a big advantage in the ice saving, to say nothing of the milk companies and the ice cream manufacturers. I can't see what the element of cost has to do with delivery at times like this, and even what slight difference there is against our trucks is nothing compared with our maintaining service. Our horse trucks — for we still have many of them — have been less than half as efficient as in ordinary times, and within a week two of our best horses have been prostrated by the heat."

Merchants, manufacturers, farmers, public and private service corporations — all have been benefited by the motor truck. In truck-farming zones where quantities of perishable produce must be quickly gotten to market, enterprising men have invested in motor trucks, and make it their business to collect loaded wagons of fruit and vegetables at stated points, which are hooked on as trailers. On Long Island one can sometimes see as many as eight loaded wagons composing a truck train going to New York to market.

In municipal service the motor wagon and truck are replacing horses for ambulance, patrol, street cleaning, garbage removal, and fire engine service. A single month's reports (August, 1911), disclose expenditures, contracts, or appropriations aggregating a total of nearly $425,000 for self-propelled apparatus in seventy cities and towns, scattered through twenty-four states. New York City alone expended $710,000 in 1912 to motorize its fire department.

As an extraordinary example of the reliability of the motor truck, the American manufacturers of a well-known truck of Swiss origin took a four and one-half ton demonstrating truck that had already been run 3,500 miles, loaded it with a 7,000 pound cargo, and sent it across the United States over the worst route they could select, and at a season of the year (March, 1911) when the roads were very much worse than their average bad condition. In spite of ice and snow, body deep; mud and sand over the hubs of the wheels; boulder-strewn watercourses doing duty as highways; freezing, thawing, and "boiling" temperatures; hills that rose one foot in every three; rivers that washed the flooring of the chassis when the truck was driven across the fords — in spite of every hindrance that had been foreseen and many that had not — the "Pioneer Freighter," as this Ocean-to-Ocean truck was called, overcame every obstacle and pushed its way

A good 5-ton motor-truck can deliver as high as 60 to 70 tons of coal per day. A horse-truck of equivalent capacity rarely delivers more than 30 tons per day

This patent post-hole digger and derrick-truck automatically digs holes and plants poles for overhead line construction with more than 300% economy over manual methods. It is used by the Bell Telephone Companies for telephone line construction service

through without a minute's faltering of the mechanism, without the bending or breaking of a part, except the buckling of leaves of the forward springs when the truck broke through a light bridge in the dark. This was the first motor truck that ever accomplished such a feat; it did what had been declared impossible for a motor truck. A more exacting test of the power and endurance of a modern machine could not have been devised.

With the growth of our cities and the increasing density of traffic on our streets, the day is not far distant when no system of traffic regulations will prevent the congestion which is already costing us hundreds of thousands a year in delayed deliveries. The utilization of power wagons for delivery would bring about prodigious economy in the available street capacity, but its importance has been not generally recognized, except by a few students of urban transportation. The streets of our cities contiguous to docks or freight terminals especially, present today the most disorganized, chaotic, and disgraceful scenes — a crying need of modern system and efficiency. The use of power trucks would help to remedy this, especially if the owners of piers and freight yards would admit power trucks to their loading platforms, because a power truck moves faster and takes less space.

Mr. Charles E. Stone, a prominent truck expert, has presented some interesting figures which show the

great economy in space on our streets which would result from the substitution of trucks for horses. A horse delivery wagon has an over-all length of about eighteen feet and occupies ninety square feet of area. To stable the horse and wagon requires about one hundred and fourteen square feet of area. The motor of like carrying capacity will average an over-all length of about ten feet, or sixty square feet of area, whether on the street or in the stable, a saving of practically one-third on the street, and nearly sixty per cent. in the stable, where the high rental value has to be considered.

The comparison with large drays is even more striking. The five-ton horse truck will require about twenty-five feet on the street, or two hundred square feet of surface, and the stable space for this equipment would represent two hundred and eighty-one square feet. A motor of equal capacity would require only one hundred and seventy-six square feet.

While these figures show a very decided saving for the motor as against the horse, conservative estimates prove that it is doing two and a half times the work of the horse, making a saving of street space of no less than seventy-three per cent.; so the same amount of work could be done with only about one-quarter of the street congestion, or four times the present volume of traffic could be accommodated before relief measures would be needed.

We have legislated against the house-fly and the mosquito in our cities as enemies to man's welfare, health, and hygienic comfort. The congesting conditions of centers of population now demand that we legislate the horse off our streets. The horse as a purveyor of filth which serves as the breeding or culture medium of flies and a variety of noxious germs is doing more than any other agency to prevent the proper sanitation of cities. He is costing us hundreds of thousands — millions, even, to keep our streets tolerably decent, and he is spreading contagious diseases at a frightful rate.

In economy of space, in cleanliness, in the rapidity of delivery, and in reliability in all weather, the power truck is far ahead of its horse-drawn competitor. One is the twentieth century method, the other belongs to the centuries preceding.

But then comes the question of cost.

The cost of operation of a gasolene truck, which is taken for illustration because it is considered more expensive to maintain than an electric truck, but is capable of doing service for which the latter is unfitted, is:

GASOLENE MOTOR TRUCK COSTS

	10 Ton	5 Ton	3 Ton	1 Ton
Chassis cost	$6,000	$5,000	$3,000	$1,500
With stake body	6,300	5,250	3,225	1,700
Average miles per day	38	50	60	80

Per Year

	10 Ton	5 Ton	3 Ton	1 Ton
Depreciation (15% less cost 1 set tires)	$780	$695	$421	$225
Interest, 5%	315	262	161	85
Driver, $16 to $22 per week	1,144	1,040	936	832
Garage	300	300	240	240
Tires[1]	1,650	930	620	300
Yearly overhaul and current repairs	550	450	400	300
Gasolene at 12c.	450	450	375	275
Oil at 30c.	120	90	60	40
Insurance	220	200	150	125
Cost per year	$5,520	$4,417	$3,363	$2,422
Cost per day	18.43	14.72	11.21	8.07

Here we have nine separate and distinct items. The first group is made up of four items which are practically constant in all makes of trucks of equivalent or nearly similar sizes. These are interest on investment, insurance, drivers' wages, and garage charges. The second group of operating cost items, consists of outlays which are of less importance — gasolene, oil and grease, and depreciation. Good engineering, design, and construction affect all these four charges; but, while the quantity of gasolene and oil consumed should be reasonable for the service the machine does, the quantity consumed is not necessarily vital to the success or failure of motor-truck operation. Depreciation more properly should be figured in the group of constant or fixed charges. Manufacturers differ

[1] Since this data was compiled the price of tires has gone down about ten per cent.

ieir estimates of what should be charged off for
:ciation, as no sufficient number of well-built
r trucks have been in service long enough to figure
'ately what the yearly depreciation should be.
;ure of fifteen per cent. is conservative for the
al depreciation of a standard, well-made business
r vehicle. The third group, operating cost, com-
; tire maintenance and machine overhauling or
:ep. If a truck or delivery wagon is fitted with
roper sized tires and is geared to the right speed,
ire cost can be predetermined in a similar manner
ie fixed-charge items. Tire manufacturers now
intee a specific number of miles for each tire. A
r vehicle owner has merely to figure out his daily
ge, divide that into his guarantee, divide this
ent into the price of a set of new tires, and set
mount aside every day as a tire-amortization fund.
fund should be kept distinctly to itself the same
ie gasolene fund, drivers' wages, or any other
ise.

ɔusiness vehicle should be thoroughly overhauled
a year in the manufacturer's or dealer's shop by
nen familiar with its construction. At this
worn parts can be renewed, new bearings put in
: necessary, and every part examined for flaws.
retically the annual overhauling should make
fe of a machine indefinite, but its practical result

is to double or even treble the life of the vehicle over what it would be without overhauling.

The tables below made by Mr. A. N. Bingham, a prominent motor-truck expert, were compiled from the experiences of a large number of business firms extending over a five-year period.

COMPARATIVE COST OF HORSE AND MOTOR

Horse-Drawing Wagon

	Cost Per Day	Tons Per Load	Daily Average Miles	Miles Loaded	Ton Miles	Cost Per Mile Loaded One Way Only
1 Horse	$4	1	22	11	11	36c
2 Horses......	6	3	20	10	30	20c
3 Horses......	8	5	18	6	45	18c

Motor Truck

	Cost Per Day	Tons Per Load	Daily Average Miles	Miles Loaded	Ton Miles	Cost Per Mile Loaded One Way Only
1 Ton.......	$8	1	80	40	40	20c
3 Tons	12	3	60	30	90	13c
5 Tons	15	5	50	25	125	12c
10 Tons	18	10	38	19	190	9½c

Let us further inquire into the economy of machine hauling by citing a specific example from the experience of users of business power vehicles for (1) heavy delivery; (2) light delivery; (3) city transportation, and (4) suburban transportation.

The coal business is an example of heavy work which presents singular features. The coal business

cessarily a seasonable one. In winter it requires ivery service of great efficiency and in the summer iaratively little. The disparity between the two itions has long been the source of much loss, and the arrival of the power truck there was no remedy. y Fall large companies would be compelled to buy reds of heavy horses, use them a few months, and e Spring either sell them off or turn them out to their heads off" in idleness. In either case, these s were a source of large loss for which there could return. A certain large coal firm in New York d the problem by buying thirteen ten-ton power s, and it estimates that one such truck displaces horses. When the summer dullness comes in coal ery, this firm lays the power vehicle up in its own e, overhauls and paints it, and carries on deliveries horses. Instead of sacrificing about one hundred twenty-five horses or keeping them at heavy ex-, this firm now stores the power trucks at the only of interest and insurance. According to ully kept records the average performance of trucks was as follows during the winter of 1910–

THE COAL TRUCK RECORDS

Average no. of trips a day	8.88
Average no. of tons delivered	93.00
Average no. of miles traveled	32.33
Average cost of delivery	20 cents a ton

The operating costs per day of these trucks averaged on each one:

THE COST OF THE COAL TRUCKS

Depreciation and interest	$6.17
Garage charges (at $35 a month)	1.17
Gasolene	1.95
Oil	.56
Driver	3.39
Amortization fund for tires and repairs	5.00
	$18.24

The tires lasted seven and a half months, including two months of night work, or an equivalent of more than nine months in all. The depreciation was figured high because the trucks were used day and night during the winter. During this time the saving over the cost of horse delivery amounted to fifty per cent. At other times it amounted to thirty per cent.

In the city of Indianapolis a proprietor of a vault cleaning company is operating a three-ton gasolene truck which is effecting a saving of $103.44 a month over his former horse-drawn wagons. The machine displaced four wagons and eight horses, which with harness, etc., had cost $1,808, and which cost $424.73 per month to operate. The itemized cost of operating the truck was:


12 Tons

In this picture the upper part of the combination type body for a farm truck has been removed, and the lower body is being loaded with top-soil for greenhouse use

This 6-ton motor-truck was used by a firm of engineering contractors in New York for construction on the Catskill Aqueduct. From well-verified records, this particular machine did the work of 12 double teams, costing $5.00 per day each. Its average daily performance was 9 trips over a 7-mile road

OST OF OPERATING THREE-TON TRUCK (PER MONTH)

One driver at $75	$75.00
Three helpers at $45	135.00
Gasolene bill	38.23
Lubricating oil and grease	5.40
Recharging storage battery	.50
Repairs to (steel) tires	5.00
Tire depreciation (set aside)	6.00
Interest on $2,500 at 6 per cent.	12.50
Depreciation at 20 per cent. per year	41.66
Painting and re-lettering	2.00
Total cost per month	$321.29

ie experience of a large laundry constitutes a good
iple of the economy of light delivery service.
power wagon of 500 pounds capacity leaves the
dry at 7 A.M., and returns at 3 P.M., averaging
iiles and making 139 stops. The route of this
in is made up of unpaved streets for half the dis-
:, which makes much slow speed work. In cover-
he same route with a horse, it is necessary to leave
aundry at 7 A.M., the first stop being six miles
'. At noon a relief wagon is sent out with a second
which is transferred to the first wagon. The
id wagon then works all the afternoon and returns
ie laundry between 6 and 8 P.M. With the auto-
in the return trip is made to the laundry for the
id load, thus saving the work of an extra horse

and driver. Analysis of the statistics shows the total cost of operating two one-horse wagons in one day to be $5.11, including wages for two drivers at $2 per day each, hay and oats for two horses at 75 cents, depreciation at the rate of one cent per mile, 36 cents. The total cost of operating the delivery automobile is $3.19 a day, including one driver's wage at $2, total operating cost of 47 cents, with depreciation figured at 2 cents per mile, or 72 cents. The saving is thus $1.92 per day for the auto-wagon over the horse wagon, a sum which would nearly pay the first cost of the power wagon in one year's service.

An example of city transportation drawn from the experience of a milling company in a large city delivering flour to the trade, furnishes valuable data for the comparison of a horse-drawn vehicle and gasolene power-truck delivery service. The first test covered eighty-eight consecutive working days in the months of October, November, December, and January. The second consisted of an eighteen-day test in which a horse truck and a motor truck were used side by side, each vehicle carrying the same kind and weight of load. During the eighty-eight day test, the power truck made 2,171 deliveries in 621 hours, aggregating 925,623 pounds, which is an average of less than seventeen minutes per delivery, twenty-five deliveries per day, and 426 pounds for each delivery. The mileage

red in the four months' test was 2,784, which is an age of nearly a mile for each delivery. The conption of gasolene was 290 gallons, and of oil 25 gallons, the cost of which averaged 2 cents per delivery of 426 pounds. On the eighteen-day of horse versus power truck, the latter made 418 eries in 114 hours, covering 560 miles at a total of $8.76, or an average of 4 cents per delivery; eas the horse truck made only 132 deliveries in hours, covering 110 miles at a total cost of $7.49, n average cost of approximately 6 cents for each ery.

ie experience of a large Brooklyn, N. Y., depart-t store is of particular interest to the prospective ell as the actual user of power wagons delivering rban merchandise, as it indicates just what may cpected under actual service in all kinds of weather, it affords an excellent basis of comparison by which heck up expense accounts for transportation. en trucks (one three-ton and the remainder one-displaced thirty-three horses. The cost for six ths was $8,709 for the horse delivery, and $7,349 he electric trucks, a saving of $1,360 in favor ie machines, which, itemized, shows the following esting tabulation:

Truck	Mileage	Power Cost	Maint. Cost	Overhead Cost	Total Cost
A	7808	$141	$348	$465	$954
B	7722	147	361	469	977
C	8157	151	277	459	887
D	7935	149	201	474	824
E	8727	158	323	470	952
F	7677	146	241	474	860
G	8071	150	250	455	854
H	7406	134	290	458	882
I	7864	147	281	459	887
J	8584	152	281	470	904
K	6041	100	539	471	1111

The figures are for a six-months' period from August, 1910, to February, 1911, covering exactly the same service that had been performed a year previous by horse-driven vehicles over eleven of the long routes of the company. In both cases, the salaries of drivers and helpers were the same and, therefore, not a part of the comparison. The horse service on one route was formerly assisted by shipment of the goods by express ten miles out to a distributing point from which the wagon operated, whereas the power wagons cover this twenty miles by starting from the main store, thus saving the express charge.

The item of "power cost" in these figures is materially reduced in this firm's case by using charging current for the batteries of these wagons from its own plant at only 2 cents per kilowatt, whereas the usual commercial charge is about 6 cents. Maintenance

cost includes garage and other labor, supplies, and any work done on the cars, and "overhead cost" is made up of such items as rent, insurance, interest, and salaries. Further analysis of the table discloses a cost per package by machine delivery of $3\frac{3}{4}$ cents. Excluding the three-ton truck, the cost per mile by machine delivery is a trifle over 11 cents.

"We are not disposed to attribute to automobiles any of the extravagant economies one hears of sometimes in that connection," said a member of the firm in discussing the matter, "but it cannot be denied that the service is decidedly better than the service that horses gave, and we find that the results are more than we had expected. Ten years ago we bought four electric cars and tried the experiment, but it came to a dismal failure, and we were glad to sell the cars for less than ten per cent. of what they cost us. Since then there have been marked improvements in cars and batteries, and we have been much interested in working out the present experiment with the fleet of eleven cars.

"I am still of the opinion that horse trucks have their own value and may still be relied on very strongly, but we feel that a reasonable proportion of automobiles can be intelligently made use of to great advantage. Our service is more extensive, more expeditious, and more reliable, and we discover on compiling results

that there is also a real saving in money. Our trucks are making in some cases fifty to sixty miles per day and our limits of service have been considerably extended.

"I have been especially impressed by the cost of making deliveries by express, which we formerly found necessary between the store and one outlying district station from which our house-to-house delivery was made. Goods sent by express formerly involved twelve per cent. expense, whereas we now cover it with our own truck for about eight per cent. A careful comparison of our figures leads to the conclusion that the experiment proves the value of the automobile for the longer runs of our service; we have not applied it to our nearer city deliveries as yet."

The motor truck is being used today in one hundred and twenty-five separate and distinct lines of trade and industries, and newer fields of adaptability are constantly being found for it. Practically every business and industry in which transportation is a necessity — and there are few in which hauling materials or goods is not required — has been invaded by the horseless wagon. The Government has authorized the purchase of twelve hundred motor trucks to displace mule teams in the commissary department.

The motor-driven street-cleaning machine has already appeared in several cities. Last winter a city

contracting firm in New York took their seven-ton motor truck, fitted a type of board snow-plow to its front end in diagonal fashion so as to sweep the snow aside in a continuous heap, and, in an eighteen-hour use of it for the city, did as much work as two hundred street-sweepers would have been able to do in the same time. Figuring the wages of the sweepers at $2.00 per day, the machine earned $800 for its owners, and as its cost was but $15 per day to operate, it is obvious what a tremendous saving such a machine can effect.

In the metal mining districts of the West the motor truck is slowly but surely coming into its own both as a single unit to haul ore to smelters and the refined metal to shipping points, and as a "road locomotive" to haul "trailers" of loaded ore wagons. With loads of more than thirty tons these mining "truck-trains" are operated at speeds of five to six miles an hour, and they travel the rough trails of Arizona in places on grades as high as 12 per cent.

In mail service the motor wagon and truck are daily growing more common. For express service the four leading American companies have already invested $2,500,000 in motor trucks to facilitate the prompt and economical handling of packages. In this age of speed even the undertaker has motorized his funeral cars to hasten our transportation to final resting places.

This is the uncolored status of the motor truck. Service first — it is faster and more reliable. Saving second — but usually where modern trucks are installed there is a distinct saving. This is for the owner. For the cities it means cleaner streets and less congestion; for the suburbs, service that was beyond the horse-drawn radius.

Perry Sand Company, owners of these patent automatic dump-trucks, write that one of these machines cut their delivery cost in half

Type of 5-ton motor-truck used in the United States Army in the summer of 1912. This truck did the work of four-mule teams transporting camp equipment

This is a 15,000-pound contractor's dumping-truck, which is operated automatically by the driver from his seat. The body tilts to a maximum angle of 45°, and the load can be entirely dumped in a heap, and the body restored to the bed of the chassis, in seven seconds

CHAPTER III

AT MOTORIZED HIGHWAY COMMERCE MEANS TO THE BUSINESS WORLD

THE economic considerations that enter into the substitution of motor trucks for horse transportation in practically every line of commer- enterprise go deeper than perhaps most people d think. That the removal of horses from city ts tends to cleanliness, to sanitation, and to the efficient handling of congested traffic; that motor cs by their greater speed and endurance, broaden owner's selling territory beyond what can be ıed by horse service; that motor operation is more omical than horse operation, — all these things recognized, in a general way, by most business That there may be a connection between the cost of living and the high cost of maintaining transportation equipment is not so obvious to casual observer, though there is ample ground for ecting the two things.

ıe evidence in this connection lies in the increased of living, so to speak, for horses as well as for

human beings. The cost of living has grown in nearly exact proportion, for animals and for men. Accurate calculations from the actual market reports show that in the last five years, the cost of feeding a horse has increased 137 per cent.

A horse's feed is produced by the soil on which the food for human beings (whether grain, vegetable, or flesh) must be raised. Even with its enormous acreage of unused land, the United States imports each year more of the things that are grown from the soil. Therefore, one of the easiest and most evident ways to reduce the cost of living for men, women, and children, is to devote to producing food for them much of the acreage now used for raising food for draught animals. This sounds theoretical and fantastic at first, perhaps; but the hard test of plain figures shows it to be practical and common-sense.

There is not a point at which the motor truck is not cheaper to maintain than the horse. For example:

To give the utmost working efficiency, a horse must be stabled near his work. Not only is the time it takes to drive him from the stable to the job just so much lost out of the working profit-units, but every step of the way is taken from the distance he can travel in his day's work. A horse, being flesh and blood, has limited endurance. A machine, if properly built and suited to its work, has practically no limitations.

[T]he necessity of stabling horses near their work to e both time and strength going to "the job" and ırning from it, means a constantly increasing enditure for housing. For in cities, and even ns, stables frequently must be located in districts fast-rising property values. The motor-truck, on other hand, suffering no weariness of the flesh, l having from twice to six times the speed of the se, can be housed at any distance from its working e that may be desirable for economy.

Again, the garage is not the unsanitary nuisance that horse stable is; and as a single motor truck, prop- r used, will do the work of from three to six two- se teams, it is fair to calculate that the motor-truck ıipment required for a given amount of work will upy no more than one-fifth the floor space required horse equipment. This allows for the space occu- d by wagons, horses, feed, and so on.

uch differences in the cost of maintenance are reciated by most men who have given their trans- tation service serious thought. But there are other nents in load-moving costs which are not so obvious il you begin to dig down. The fact that many a ster of transportation began as a stable-boy, be- ıe a driver, and has been promoted to his job at the d of delivery and trucking service because of his wledge of horses and how to get the most out of

them, puts a good many business men at a disadvantage in solving transportation problems, because the advice they receive is not disinterested.

Neither, for that matter, is the advice given by a maker of motor trucks disinterested in a sense. But every successful business manager knows that part of his success is due to the fact that he has pushed the sale of his commodity, whether it is a manufactured product or some kind of service, in the direction in which he knew it would absolutely make good. A motor-truck concern which has proper regard for its future and its commercial standing will not advise the substitution of motor trucks for horses unless there is a certainty of their proving profitable, either by making a saving or by extending business, or in both ways.

One of the most interesting of modern commercial advisory agencies is the traffic and engineering department of the motor-truck companies which are said to have real records of the performance of different types of machines extending over any considerable period of years. It is the experience of the engineers of these organizations that the master of horse transportation, when he figures the expense of his department, frequently overlooks or omits such items as veterinary expense, and loss of a horse's time by reason of sickness, which involves having spare animals that cannot

be used economically. For instance, one large concern which motorized its transportation after a searching investigation, discovered to its surprise that its wagon service was costing $2,000 a year more than it had been reckoning on in the mere matter of veterinary advice, to say nothing of treatment or the cost of having an animal's work done for him while he is sick.

Horses that are used carefully will not work more than fifty per cent. of the working days of the year. It is possible to get seventy-five per cent. of the working days out of a horse, but this is done at the expense of his endurance; he wears out more quickly. On the other hand, a good motor truck is in prime condition ninety per cent. of the time, taking out all the time lost on repairs and adjustments. And, in ninety per cent. of the year's working days, the motor truck will work practically twenty-four hours a day if necessary; that is to say, it has no moods, it is never "half sick" and so to be coddled; when it is in commission, it is up to full efficiency the whole time.

One of the minor economies of motor trucks that is frequently pointed out, is that they do not eat when they are loafing. That means that fuel expense stops every time the truck stops, in a well-constructed car. There is no Sunday feeding, no holiday feeding; no Sunday or holiday exercising or cleaning, or other care. And while only a special man can look after horses,

a competent mechanician, who may be any good mechanic instructed by a motor-truck engineer, can give motor trucks the necessary supervision.

There is another important consideration in the difference between motor-trucks and horses as investments. A horse grows old every day, whether he works or not. He is wearing out with age all the time, even if he spends most of his hours in a stall. The motor truck wears only when it is in use; when it is idle there is no expense connected with it whatever, except the interest on the investment. And a horse costs interest on the money invested in him in the same way.

Few concerns would re-equip themselves with horse transportation now. A horse that has been used for delivery or hauling service, especially on city pavements, is of little value for any other use when he is too far gone to be valuable for that. An old wagon or horse dray is absolute junk. It costs more to patch up and renew superannuated horse equipment than it does to entirely re-equip with motor trucks that will do the same amount of work.

The use of motor trucks is still a recent thing. In the very early days, mistakes were made by both builders and owners, and some of the wrong impressions which took root then have grown and spread since. For instance, to get the most value out of a motor truck by both saving money on present de-

livery costs and extending the selling area of a business, it is necessary, of course, to lay out the transportation system anew, making it fit the changed conditions. One truck will do the work of a horse and wagon a good deal better than the horse and wagon will do it; but it would do it wastefully, because, like every other machine, a motor truck must be kept in constant motion during working hours to earn the full profit of which it is capable. Unless a business uses at least three horse wagons, it cannot use one motor truck to advantage.

The amount of money involved in motorizing a business has sometimes caused hesitation, even when the management of the business was convinced of the value of motor trucks in a general way. Yet a study of actual experiences shows that a good truck not only pays for itself surprisingly soon, but earns enough more in a short time to pay for the horse equipment it has displaced, and after that it is a steady dividend producer.

The practical and economic reasons are working together for the rapid motorizing of every business which uses transportation. The economic reasons will, naturally, be the last to be recognized; but the everyday, practical reasons are in themselves sufficiently obvious to carry on the evolution with steadily increasing rapidity. The experimental stage of the motor

truck is passed. There are makes of trucks which have been in use so long and under such a variety of conditions that their performance is a fixed factor which may be counted on absolutely. The wise business man with his skill in making efficiency tests, and his measuring of costs against profits, can apply to his particular concern the technical and engineering knowledge which the expert automobile engineer will provide for him.

CHAPTER IV

MOTOR TRANSPORTATION CONSIDERED IN THE LIGHT OF SCIENTIFIC EFFICIENCY

HABIT is the basis of most of our methods of doing things; too often it is the "wet blanket" which smothers the spark of human progress.

Today, one of the greatest hindrances to the more rapid utilization of mechanical transportation is that the horse has pulled highway vehicles for thousands of years. Thus the "animal standard" of efficiency has fixed itself so firmly in the human mind through heredity's influence that even the wide-awake business man unconsciously thinks of the efficiency of motor trucks in terms of horse standards.

This horse-unit habit of thinking of commercial transportation is very largely responsible for most of the skepticism of the business public in regard to the power truck — for the doubt that still prevails among 75 per cent. of the business world that the motor truck has really "arrived" as the next link in the chain of transportation evolution *after the horse.* The

horse standard of efficiency accounts also for much of the false figures of transportation cost and for seven-eighths of the so-called "truck failures."

In truth if the horse had never been used by the human race to pull vehicles the motor truck would now be taken at its true value. Its maker, and the man who is or ought to be using motor transportation, would be closer together and see their mutuality of interests — their interdependence in the scheme of advancing civilization.

Not an inconsiderable number of salesmen of motor trucks endeavor to introduce motor transportation by tirades against the horse, forgetting that the horse, as a horse, is not at fault at all — that he (the horse) is not the cause but the victim of our changed economic conditions. These superficial promoters of mechanical haulage do not seem to grasp the broader idea in dealing with the business world which unfortunately has gotten into the habit of thinking of trucking efficiency and costs and problems in terms of horse service, effectiveness, capacity, and cost.

Horse comparisons make it harder for the manufacturer to sell power trucks and restrict the user of motors to a traditional line of efficiency ideals which are entirely misleading. If the horse ideal of efficiency was non-existent some factors which retard the motor would disappear.

That percentage of the business world which is

ccessfully operating motors has started out with the ɜal that the broad and intelligent way to consider ɔtor-truck service is to start with the problem of ınsportation on one side and the motor truck on the her. Then, wholly ignoring that the service was ever rformed or could be performed by another agency, ey have evolved the most effective intelligent and ɔnomic use of motor equipment to serve the necessi-s of each peculiar situation. Worked out on this ɔad-gauged basis, very few motor-truck installations ve ever failed to succeed beyond reasonable anticipa-ıns. Some of the greatest successes of motor instal-ions have been made by introducing the power truck new businesses where the horse was never known, d where, therefore, the men were unhampered by rse traditions and ideals.

Unprejudiced fairness to the motor truck demands ɜ concession that the service it does is not properly mparable with horse service and for the following ısons:

Granting that in average service, one high-grade ɔtor truck will displace four teams — it must not thought that it performs this work in the horse y. While it does the *same service* it does it in a ferent way. It is faster, surer, independent of ather extremes, independent of fatigue, independent hours for rest and feed, and free from bad temper.

It occupies less space in streets, docks, terminals, and the owner's garage. It does cleaner work, permits the employment of more skilled and efficient labor, and stays at the job without stops for twenty-four hours if required.

As an emergency tool the machine has a dependability that no horse has. It can be taken off the job for months when the busy season of the owner's deliveries are over, and its only cost is the interest charge and the "dead storage" rental for the space it occupies.

Again, both in theory and within reasonable practise, the power truck never becomes a "dead horse." It can always "come back," through the ease with which any of its "vitals" can be renewed when worn out; and when constantly and intelligently repaired, it is always at the point of highest efficiency.

Furthermore, the truck can deliver loads to restricted places where horses cannot go — alleys, platforms, docks, etc., and can there unload with its own power. If, instead, horse deliveries must be made, the loads must be carried as near as horses can go and the load then discharged piece by piece by tedious and expensive hand labor.

Even a light duty motor truck will carry "on its back" a load equivalent to the pulling power of four horses with only one man in charge of it, as against a minimum of two men for equivalent horse equipment.

If, to take a concrete example, the load is lumber in both cases, the two attendants for the horse equipment must be increased by two or three to get the load off; whereas the driver of the power-winch equipped motor truck may, alone and in a few minutes, discharge his entire burden. Hence it must be clear that it is the *character* of *service* given by power trucks that vitiates any comparison between them and horse trucks. The machine renders service in many respects not possible to horses. Consequently it ought not to be measured by horse units. However, the *force of habit* and *horse ideals* often cause it to be so judged.

Transportation efficiency doctors are coming to appreciate that the purely utilitarian features of motor transportation are still but partially developed. We are still prone to think only in terms of horse utility. As a "traction engine" the horse's value is limited strictly to drawing the load. The traction and the carrying capacity of the motor truck but partially represent its capabilities. To understand the efficiency of the motor truck still further, we must think of the easy adaptation of its power plant for operating derricks and winches and cranes — even taking the crane and its load over a wide distributive area.

The power-winch equipped motor truck may use the engine power which propels the truck to load and

unload. The same engine may drive an electric dynamo, carried in the truck, to run stationary tools in the shop.

The engine's exhaust may be used to heat the truck to make the driver more comfortable or to protect a load of perishable produce from freezing. On the other hand the power truck's versatile motor may operate a refrigerating plant carried on the truck, to protect perishable products from spoiling in the opposite extreme of weather. These subsidiary and constantly widening services of the power truck represent *quality* of efficiency, *character of work* for which the horse is useless.

It must be confessed that today the average motor truck goes into service under horse-pace standards in the smallest details. Its owner, regarding it by the light of horse ideals, puts it to work distributing his goods over routes adjusted to horse capacity, thinking of it purely as a substitute for a horse team. He loads it from a platform or a warehouse designed solely for the limitations of the horse team. He unloads it after it has waited its turn for maybe an hour at a similar misfit delivery place. The aggregate of its "off duty" or stationary periods runs into hours per day. When capitalized on its initial cost ($3,500 as an average) the dividend-earning capacity of the power vehicle *plus wasted opportunities* spells

'ruck failure." Efficiency engineers are daily showing
at many of these "truck failures" are the fault of
e owner and not of the truck. They throw aside
l horse traditions and reorganize the operating system
mpletely, thus producing economies that astound
e owner.

The great and fundamental causes of "truck fail-
'es," are: Truck users forget that the machine is
ıe of the biggest potential tools for efficiency in busi-
ss that the twentieth century has so far given us;
at a new régime must be put into force when they
lopt it; and that this régime demands the highest
'der of systematizing and reorganizing ability for
e entire delivery system — both *inside* and *outside.*
Grounded deeply in horse traditions, probably but
ıe "master of transportation" or delivery superin-
ndent in twenty-five is capable of handling such a
organizing problem. A "transportation doctor's"
rvices are needed at the start to so plan the system
ithin and *without* that the modern mechanical wagon
n be kept constantly at work.

So far as planning the "without" part of the new
stem is concerned, it is the office of the truck manu-
cturer to educate his customer through the traffic
partment or "efficiency doctors." The "within"
rt of the system must come by a process of evolution
hich motor transportation is bringing.

Existing buildings must be altered to facilitate motor-truck delivery. Doors must be sufficiently large to allow the entrance and exit of the largest trucks with enclosed bodies. Courtways must be equipped with turntables, traveling belts, movable platforms, slides, chutes, and other modern efficiency apparatus for quickly putting the load on and off. These must be utilized before the potential possibilities of motor transportation can be developed.

Even the new highway and street must come to be capable of handling loaded vehicles weighing up to fifteen tons. The architect, the civil engineer, the highway constructor, the common carrier — all alike must co-operate to develop all the possibilities of commercial transportation. This is one of the greatest business problems of today.

The "horse ideal" has gone even deeper than this in retarding the use of motors. The cost of a good motor truck is the first objection two-thirds of its logical users raise against it. Yes, initially, motor trucks do cost more than horses. But every proof has been given that when intelligently used they are worth more. All comparisons are in favor of the motor truck.

It is, however, freely admitted that some conditions still exist, and will exist for a long time in the future, where horses have the advantage. In such cases all honest "transportation doctors" will advise the reten-

A 5-ton lumber-truck in the service of Herckhoff & Cozner, Los Angeles, Cal. This truck is equipped with an extra long platform (18 ft. 2 in. in length) and carries lumber up to 26 feet in length

In this picture the owner has fitted a bolster over the real axle of his 5-ton truck, and by means of the trailer unit carries timber 60 feet in length. Eight teams would have been required to do equivalent work

This picture shows a large and heavy piece of shoring timber being pulled as a trailer-unit by a 5-ton motor-truck. It would have required 6 horses to pull this timber, and their "wheel-base space" would have been three times that of the motor-truck with a trailer; thus economizing space in congested city streets, and preventing the obstruction of traffic

tion of the horse. But new types of motors are being rapidly developed which can do the work under these special conditions better than the horse, because of having far greater reserve capacity and endurance.

In conclusion, the line of reasoning developed above is not intended principally to condemn the horse. Rather the intention is to show that the motor truck as a new utility has new powers and new possibilities. The horse, we thus repeat, as an animal is not at fault at all. He is the *victim*, and not the *cause*, of the modern demand for scientific management in all affairs of business.

In the light of the Emerson principles of efficiency we must forget horse traditions and abandon horse standards of service, when the machine is considered. When this truth is fully accepted among transportation users, less agitation over "relative" costs will result and greater progress in getting the unrealized opportunities of motor transportation will follow.

CHAPTER V

THE PASSING OF THE HORSE

WHY THE CAUSE OF CIVILIZATION DEMANDS A HORSELESS AGE

IT has been the fashion of automobile press agents, since the days when the first queer-looking contraptions called "horseless carriages" began to appear, about 1899, to speak in glowing terms of the Horseless Age that was to come. With superlatives and striking similes they have painted a picture of poor old Dobbin looking upon his new-born rival with such horror that it caused his sudden dissolution. According to these wild dreamers, we would, by the year 1915, look upon an equine quadruped on the streets with as much amazement as if he were some wild beast from the Palæolithic Age suddenly come to life again.

Let us inquire whether the Horseless Age prophets have forecasted rightly in their beautiful vision of this Horseless Age.

According to the "Year Book" of the Bureau of Plant and Animal Industry of the National Bureau

of Agriculture, in the United States in 1900 (about the time the first pleasure automobiles began to appear) there were 15,506,000 horses and 2,753,000 mules. In 1911, so the same authority tells us, there were 17,344,000 horses and 3,754,000 mules, an increase of twenty-five per cent. in a trifle over ten years.

Again we are told that in 1899 the average price of horses in the United States was $64. By 1911 the average value had increased to $108. All of this time our Horseless Age prophets have been telling us that we are on the threshold of an era when the horse will be relegated to the same position as the rare fauna and flora of the museums.

We are compelled to ask ourselves the question, "What has the horseless vehicle done to bring about the passing of the horse?" The answer is, "Practically nothing, so far." The most potent influence of the pleasure automobile has resulted in driving the horse not into oblivion but mainly into commercial and agricultural service.

The statistics of the number of horses in use for drawing pleasure vehicles in thirty of our largest cities show in ten years a decrease of approximately twenty-five per cent. On the other hand, the percentage of horses devoted to purely commercial service has increased about 33⅓ per cent. in the same ten years. The mechanical wagon has, up to the present time,

caused the displacement of only about 200,000 horses in the entire country, figuring that in the year 1912 approximately 50,000 motor vehicles are used for purely commercial service and estimating that each of these motor business wagons has displaced an average of four horses. What an insignificant percentage these 200,000 horses bear to the total number of horses in the United States today. Truly, the mechanical wagon has got to develop, to make any real impression in these vast millions of draft animals.

No, we have not yet arrived at a "Horseless Age," though we believe we are approaching it surely and steadily. At this time it must be confessed that the decline of the horse is noticeable mainly in our principal large cities.

For example, in a period from February 1, 1911, to February 1, 1912, the "wheel tax" registrations of Chicago show that the number of mechanical business wagons increased from 788 to 1,439. All told, there were 50,000 horse-drawn wagons in Chicago on February 1, 1912. At this rate of increase it would take but a trifle over five years to bring about an actual Horseless Age in Chicago.

In New York City, which has the largest number of horses in business use, the number of motor trucks increased in the one-year period from 1911 to 1912 from 2,500 to 4,500. At this rate New York's highways

of commerce should be completely motorized in the next eight years.

Champions of the motor business wagon have dilated at great length upon the economy and the efficiency of the motor over the horse. But few of these sponsors of the new art of transportation have considered that there are broader reasons than economy and efficiency of the motor which would bring about in actuality the Horseless Age.

We are shown pictorially and graphically the poor horse lying prone upon the sleety pavement or prostrated by the July sun. Yet most men are not very deeply impressed by this appeal to their sympathies on behalf of the poor abused horse. As a matter of fact, the business world does not decide questions of transportation on emotional grounds, but purely by an appeal to the reason.

Due to the fact that the horse has been with us since long before the days of the Pharaohs, the business world still thinks as a rule in "horse units." Horse traditions so surround their conceptions of highway delivery service that seeing horses put out to struggle against weather and climatic conditions is only a common feature of the ordinary course of events.

There are deeper, underlying reasons why the horse must go from urban service than the fact that he is unfitted for service in the extremes of winter and

summer. The history of transportation, like the history of a race or nation, shows a constant evolution. Man does not progress backward. The mechanical wagon has been developed because the human race has progressed to that point where it demands a different agency for propelling its highway vehicles.

The mechanical wagon is the next link in the chain of transportation evolution just as the railroad was the next step in evolution from the stage-coach. The changed economic conditions of the last twenty-five years demand the utilization of the motor wagon just as the advance of civilization demands the telephone, typewriter, elevator, skyscraper, and other institutions in our daily life now become too common to be considered anything more than necessities.

No branch of transportation shows such lethargy as is disclosed by a study of the art of highway transportation. Men are digging up every year, among the ruins of ancient Greece and Rome, highway vehicles that are but little if any different from those we are using today. Our Colonial fathers moved their goods over highways in the same manner that we are doing today. It is, therefore, but natural that we should have become so grounded in the "horse habit" through influence of heredity and custom, that we have not awakened to the realization of the actual anachronism of the horse as a "load drawer" in urban service.

When we scratch the surface and go deeper than the questions of the great economy and efficiency of mechanical vehicle delivery, we are alarmed over the enormous waste involved in the perpetuation of an animal which is productive only in the sense of being utilized for its "draw-bar pull." Even the sponsors for the horse are beginning to wake up and realize how great is the extravagance of retaining him. Very recently one of the leading journals devoted to the interests of horse owners asked the following questions in an editorial:

"What becomes of the $740,000,000 annual hay crop?"

"The horse eats it."

"What becomes of the $334,000,000 yearly oat crop?"

"The horse eats most of it."

"What becomes of the $2,000,000,000 average corn crop?"

"The horse eats a very large part of it."

The growth of population and the soaring cost of living certainly demand that the vast acreage required to produce these large cereal and forage crops be devoted to the needs of the human race. But the two billion dollars worth of food which the horse consumes every year in the United States is but a small percentage of the economic loss which we suffer individu-

ally and collectively for continuing the inefficient horse system of highway transportation. The food which he eats is but a relatively small part of the burden of the horse upon collective wealth. His depredations are far-reaching.

He requires an army of "nurses" — hostlers, stablemen, blacksmiths, and veterinaries — the aggregate number of which, figuring one man per team, totals twelve and one-half millions of our people dedicated to the task of keeping our equine population going on its four legs in a haphazard fashion. What an awful waste of human labor in this day when every branch of manufacturing and agriculture is raising a hue and cry for "Labor, more labor!"

Just consider what these twelve and one-half million men could produce from their labor in productive channels, in growing food crops to be consumed by the human population, or in the creation of manufactured products necessary to the promotion of the arts or for clothing the human race.

The enslavement of millions of men to make him fit for his very inefficient labor is but one of the many economic crimes chargeable to the equine. Look at the thousands of tons of steel which are abraded upon the hoofs of these millions of horses every year, steel which could be devoted to the erection of buildings, the manufacture of tools, the laying of new railroads,

This picture shows a type of 32-passenger motor-bus, which parallels in design, appointments, and comfort, interurban electric trolley service. It is used as a connecting link between a stretch of country at Morristown and Madison, N.J., in connecting with trolley roads

the building of bridges, and a vast number of other uses in which it would create individual and collective wealth.

Figuring the average amount of iron in a set of horse-shoes to be eight pounds and estimating that these 25,000,000 horses require six sets of shoes per year, the average horse diverts from commerce fifty pounds of iron, or a total for all of 1,250,000,000 pounds per year. If this iron is worth two cents per pound, we can charge $2,500,000 per year against the horse as a source of another waste.

If we consider the amount of leather utilized in the harness for 25,000,000 horses at an average valuation of $5 (a very low estimate), we have another economic loss of $125,000,000. This leather should be used to provide shoes for human beings, thus reducing cost of this article of clothing now growing dearer on account of the growing scarcity of the cattle supply in the entire world.

Itemizing still further the economic losses which the horse inflicts upon society, let us consider the valuation of real estate occupied for the stabling of horses in thirty-three of our largest cities. By a very conservative estimate, one motor truck displacing three double teams can be housed in one-fifth of the space these three teams occupy in a building. Assuming as a concrete case that the estimated

number of 140,000 horses on Manhattan Island were displaced at one fell swoop by motor wagons, we would have released for business and residence service approximately 225 acres valued at an average of $75,000 an acre; or a total real estate valuation of about $16,855,000.

It is safe to say that the thousands of acres required for the housing of horses in thirty-three of our principal cities have a valuation that would reach into the billions of dollars.

Nor is this all. The location of stables means the depreciation of real estate in the near neighborhood thereto. In every large city there are buildings devoted to housing horses which have driven away manufacturing enterprises and private residences. In every instance, on the other hand, when a stable is withdrawn from a block or locality, real estate values immediately increase from twenty-five to one hundred per cent.

But this is by no means all of the economic waste for which the poor horse must bear the blame. Take New York City for example. Nearly $50,000,000 from its annual budget goes to keep its streets respectably clean. The entire motorization of highway commerce on New York streets would perhaps decrease this enormous figure seventy-five per cent. It is not stretching the truth beyond its elastic limit to say

that the saving to the taxpayers of the United States through the complete motorization of our cities and towns would amount to $1,000,000,000 per year.

Again, it is difficult to prove, but absolutely sure, that the human mortality cost of the use of animals in congested centers amounts to thousands every year. The horse and the house-fly are inseparable companions and the latter breeds disease that cripples or kills many hundreds of every city's population.

But altruistic ideals are not a dominant factor in deciding business problems. The opportunity of direct personal gain in dollars and cents is of more concern to the average business man than the knowledge that a general use of a new appliance will ultimately benefit him. To justify the larger initial expenditure which the motorizing of his transportation requires, he must be convinced that the motor truck will make money for him.

The subject of the economy of mechanical delivery over horse delivery is a very big one. It is purposely avoided here because nearly every motor-truck installation has its own peculiar problems which are rarely duplicated in the same business.

Again, cost data that are absolutely accurate in motor transportation are exceedingly difficult to obtain. There are two classes of users. One that does not keep any cost records and the other who will not

allow the records to be made public property. In general, the prospective truck purchaser who clamors loudest for cost records is the last man to turn any of his own records loose after he becomes a truck user, or finding that the motor truck is effecting a saving he does not look carefully after his deliveries or keep any exact account of the saving.

The first class of motor truck users are having such successes with motor transportation and are saving such large sums of money that they are zealously guarding their secret, fearing their competitors will use the same system of delivery and thereby invade their own territory. It is not uncommon to hear the remark, "We don't want our competitors to know about the saving our trucks are making for us. The longer they stick to the horse the better it is for us. We are not philanthropists — we do not intend giving them the benefit of our experience."

The very strongest argument for the economy of the motor truck is the fact that the largest users of motor transportation in the country today are as silent as clams on the results that they have obtained from mechanical delivery. It is a certain fact that if these great motor truck-fleet users were not saving many thousands per year from changing systems, a loud howl would go forth from them that "the motor truck is a failure." There are many large depart-

ment stores, breweries, contractors, lumbermen, and meat and provision firms that are using motor trucks, not by ones or twos, but in fleets of fifty or seventy-five. It is a noteworthy fact that there is practically no complaint against the motor truck from these large systematized organizations which are using motor transportation in a scientific manner. What little complaint is heard comes from the small user who is employing the motor truck in a haphazard fashion and according to the horse standard.

CHAPTER VI

MOTOR TRANSPORTATION CONSIDERED AS AN AID TO INDUSTRIAL ADVANCE

THE old Latin phrase *O tempora mutantur, mutatur in illis* — "The times change and we change with them" — is applicable with particular force to the evolution now going on in highway transportation, a movement which in Europe began as far back as 1894 and is just now compelling the attention of the commercial world in the United States.

The history of highway transportation since the days of the Roman Empire exhibits certain phases or great turning-points marking new eras of progress, in efficiency, convenience, or economy. Historians of transportation tell us that man's first land vehicle was a boatlike structure without wheels pulled by sheer force of brute strength, first by man and then by the animals which he subjugated — the ox, horse, and mule. The next step in land transportation was by means of crude rollers run underneath the vehicle, very much on the order of the rollers

we now see in use in moving small buildings short distances.

When the revolving wheel as applied to land vehicles was developed, a great impetus was given to highway transportation; then, for 4,000 years at least, until very recently, this branch of human activity showed very little change or improvement.

When we carefully consider highway transportation in the days of the Roman Empire, and in the year 1912, we find that the greatest percentage of the world is still using the horse and wagon very much after the fashion of the Romans. We see there no great evolution in paralleling the wonderful advance that has been made in power transportation by rail or trolley. The delivery of our merchandise is done much after the fashion of five thousand years ago, although the motor, the iron horse of the highway, has reached mechanical perfection within the span of ten years. However, so great a slave is man to custom, that we find today comparatively little utilization of one of the greatest civilizing agencies and efficiency tools that so far has been given the world.

The development of this efficiency tool has gone on so quietly and at the same time so thoroughly that the world at large, grounded in horse traditions, has not yet become informed in regard to motor transportation. Only a few political economists, after investi-

gating the far-reaching effects of various systems of transportation on civilization, realize the progress that has been made in this direction.

To an investigating mind, noting the progress of the twentieth century in so many lines, it seems absurd that the human race should be using for this one purpose means that were employed dozens of centuries ago.

In saying this, the writer does not mean to convey the impression that the horse, as an animal, is to be belittled, but that he is an antiquated agency. This is due not only to the changed economic conditions of society but also to changed commercial necessities.

Students of economics tell us that the biggest problem to be met in reducing the soaring cost of living is that of efficient distribution. The difficulties of distribution must be solved if we can expect a reasonable decline from the present scale of prices for the necessaries of life.

At present distribution from the receiving terminal to the warehouse or the salesroom of the merchant costs the consumer — the public — a percentage of the final value of the commodity totally out of proportion to the cost of production.

Distribution, which is really transportation, is grossly inefficient, due to the fact that we handle our goods in the same manner that we did twenty-five years ago.

A high pressure motor hose-wagon in use at Baltimore, Md. This machine makes a speed of 40 miles per hour. In an efficiency test it threw water to a height of 160 feet

In this picture is shown a 5-ton truck carrying structural steel for the construction of a sky-scraper in Philadelphia

A picture which shows that the motor truck is built with enormous reserve strength. The truck of 10,000 pounds rating is carrying a logging locomotive weighing 22,000 pounds over a country road in Alabama; incidentally this picture shows "how not to use a motor-truck"

Manual labor is utilized to load the product on the horse vehicle and to unload it. Also, increased population has brought a greater volume of traffic to our streets, designed for the conditions of twenty-five years ago.

The resulting slowness in moving the product after it has been loaded is a tremendous factor in increasing the cost to the consumer, as the cost per unit of product is much greater than if we used automatic mechanical devices to place it on a vehicle, thus expediting its delivery to the consumer.

The horse is wholly inadequate to the present demands of the consumer because his capacity is limited simply to drawing the vehicle after it is loaded. It is impossible to adapt him to the auxiliary function of putting the load on and off the vehicle. On the contrary, machine transportation has the unique power of not only carrying the load but, through other devices operated by its motor, of placing the load upon its own body and discharging it. By means of the power winch driven by the engine of the truck, heavy bulky freight is loaded and unloaded in a manner similar to the handling of coal and freight by means of a donkey engine on the average steamship.

So versatile is the power winch that it has been used to drive a boring tool fitted to the truck. This device automatically digs holes and by means of a

derrick plants poles without the aid of human hands. The complete operation of this automatic pole digger and derrick device, with the exception of the tamping of the earth around the pole, is accomplished by the power of the truck itself.

Truck manufacturers are turning out automatic dumping bodies in which the discharge of the load is controlled by a lever in reach of the driver of the truck. Without moving from his position, the operator of these dumping trucks can discharge an entire load or a partial load and can elevate the body at any desired point, keeping it suspended at this point and regulating the amount of load that is discharged through the opening at the tail-board. These automatic dump trucks should give the greatest impetus to the building of the new kind of highways which the automobile and motor truck demand. They leave no excuse for the failure to maintain roads already constructed at large expense, as crushed stone can be spread evenly on the highway to any desired thickness. The former method of spreading by hand resulted in great irregularities of road quality.

The subject of cost of operating auto trucks must be disregarded in this discussion because general figures on motor-truck operation are very unsatisfactory and are unsafe to follow in figuring individual problems. Transportation engineers are well aware

that in a variety of peculiar cases a motor truck is not economical as compared with horse equipment. In many instances the electric-driven auto truck should be used, in other instances the gasolene truck is much superior. Only a few general conditions can be given to serve as a guide in considering the operation of motor trucks. These conditions are as follows:

1. Every opportunity should be utilized for keeping the truck in use the greater portion of the time. This demands the use of modern loading and unloading devices, such as the power of the truck itself; moving belts, elevators, or chutes; removable nest body; the Gibb crane mounted on the truck, or some other mechanical means which will rapidly place the load on and take it off the machine.

2. The truck must be loaded to its full capacity when in service.

3. The loading and unloading period of the truck must bear a small relation to the time the truck is actually moving.

4. The truck must not be overloaded.

5. On reasonably good roads the truck should be operated at normal speeds.

6. In the garage for making adjustments and repairs the truck should be under the supervision of an intelligent and competent man who knows his work thoroughly.

7. The driver must be especially trained for his work after he has been carefully selected for his intelligence, interest in his work, and mechanical aptitude. *Of all factors making for the success or the failure of motor transportation the driver is the most important unit.* Many business men make the mistake of hiring the type of driver with whom they would not trust their wives' Sunday hats across the street; and yet they give them complete control over a $5,000 investment.

Many solutions have been offered for the problem of efficient distribution of commodities after they have been brought to a common central point by the great public carriers. It is certain, however, that the present method of carrying the world's goods from point to point in urban centers cannot continue. The rapid growth of all large centers of population with the increase of traffic on our streets demands the use of vehicles that take up less square feet of space and whose normal speed of movement is such that they can quickly pass from point to point, thus lessening the congestion which today prevails to such an alarming extent in the important business streets of all cities of any appreciable size.

The greatest problem before the railroad companies, now that they have practically solved the problem of handling passengers, is the prevention of congestion of freight at their terminals. In a considerable number

of freight terminals in large cities in the last fifteen years the facilities for handling shipments with despatch have been outgrown on account of the rapid increase in the amount of freight resulting from increased population. Conditions are becoming alarming. Often the enhancement of property values is such that the enlargement of the existing terminal is out of the question, the cost of the real estate necessary being prohibitive. This situation is not a possibility of the future, but a present-day problem which is urgently demanding the best brains of the railway engineering fraternity. Many consultants have been called in by large freight handlers to endeavor to find a way out of this difficulty.

There are three possible and practical methods of solving the problem:

1. New and more rapid methods of handling the freight may be invented and give temporary relief. This idea is now receiving the best thought of skilled railway engineers.

2. Railway freight terminals may be located at longer distances from the heavy traffic zone. This seems to be the present trend of freight terminal development. It will necessitate much longer hauls to secure the distribution of freight; a situation almost compelling the use of the speedier and more efficient motor truck.

3. The railways will refuse to handle a considerable volume of short-haul freight. This third method of solving the problem of the congestion of freight at terminals offers one of the greatest opportunities for developments to the motor-truck industry.

It is no secret among railway men that they would be very glad indeed to be rid of the burden of carrying short-haul freight if they could consistently avoid it. For example, a car of freight coming from a point twenty-five miles from New York, Chicago, Philadelphia, or any large city, takes up just as much room in that city's terminal as does a car coming from San Francisco or Seattle. The expense of taking care of twenty-five miles of freight at the receiving point is almost equivalent to that of caring for the car coming from San Francisco. Every railway company would much prefer to utilize their terminals for long-haul freight from which they derive the most profit.

In several large cities, notably Chicago, the twin cities, St. Paul and Minneapolis, New York, Philadelphia, and Boston, companies have been organized for motor transportation of freight to suburban or nearby points; and the impetus given to this movement by the railway companies themselves indicates that there is a healthy demand for this kind of service. At present the major portion of all freight is carried by horse trucks to the shipping point and is again

transported by horse trucks from the railroad to its final destination. These new public service motor transportation companies eliminate the several handlings by loading the goods at the shipping end and delivering them direct to their destination.

This kind of motor-truck industry is more inviting to capitalists perhaps than any other opportunity for investment that has arisen during the past twenty-five years. The great majority of the teamsters now doing this short-haul work are ready to take up the motor truck could they find the capital with which to finance themselves. When one realizes that a first-class motor truck of five tons' capacity costs about $4,500, it is obvious that only a small percentage of teamsters who could enjoy the enormous advantages of short-haul freight business have the capital to invest in machines necessary for their purpose.

Public service motor transportation companies must build up a new clientele. Teamsters, however, already having a knowledge of existing methods of handling freight are already supplied with customers. There is, therefore, a very small element of speculation in backing this kind of endeavor.

Increasing demands are made upon all motor-truck manufacturers for the renting of trucks. This is evidence that the main drawback to a more profitable use of motor transportation is the fact that small

merchants do not have or cannot take from their business the capital necessary to purchase a motor truck. Often they are eager to turn over their delivery business to public service motor delivery companies organized on the same substantial business basis as the large railway express companies.

Unless financiers realize the opportunity for profitable conduct of such motor service companies it is obvious that the manufacturers themselves must assist promoters of such companies to find the capital, just as the great electric companies help their clients in the formation of water-power development enterprises.

The business from a public service transportation company should logically go to the horse-truck public teamster who is ready and waiting for the opportunity.

The safety of investing in machine transportation is now beyond question. It is only a matter of giving financial help to the user who is ready to adopt a new device if he can arrange some convenient way in which to pay for it. The element of speculation is almost entirely absent, as there is nothing that can occur to the auto truck that is equivalent to the breaking of the leg of a horse or the destruction of an entire stable in a short while by a highly contagious equine disease like glanders. The auto truck can always "come back" unless it has been completely demolished by accidents such as rarely occur; for each part of its

mechanism is replaceable. Theoretically a well-built auto truck should last indefinitely. Practically, however, the majority of owners will be content with ten years of hard service, which is sufficient for any reasonable business man.

The satisfaction of handling a machine cannot be compared with that of handling an animal. The freedom which the owner of a motor truck feels (when he is properly using it and keeping it in good condition for its work) is one of the biggest advantages of possessing a machine instead of horses.

His time is his own after he has placed the truck in the garage; whereas the horse owner may be called at any time to work desperately to save the life of a valuable animal; and his mind is never free from uncertainty as to whether the horse will be ready for his work the next day.

Again, the cost of feeding horses has increased at least one hundred per cent. in the past six years. Economically the time is now here when the millions of acres of land devoted to growing food for horses must be utilized for maintaining an increasing human population and keeping the price of the necessities of life within the means of the great mass of people.

The statistics of the Bureau of Agriculture for 1910 show that an average of five acres of land is required in the United States at this time to support one horse.

If we assume that fifteen people could be supplied with food from those five acres of soil by means of scientific farming, it is obvious that the acreage now used to maintain twenty-five millions of horses in the United States would support 375,000,000 people.

Those who argue that the United States could never produce sufficient food to maintain such an enormous population have not considered the possibilities of the motor wagon in reducing the cost of living. If men could realize the possibilities of motor transportation in keeping down cost of living, and these twenty-five million horses were replaced by 2,000,000 motor trucks, the acreage thus made available for growing food for the human race would in a very short time lower prices to a degree impossible, in the writer's judgment, through any other single agency.

This is not mere theory. Statistics show that of the 3,000,000 dollars' worth of green and forage crops annually grown in the United States nearly fifty per cent. is consumed by animals of service only as carriers of freight.

This economic waste due to the use of horses as freight carriers must continue to increase as the population of our cities increases with the influx of the agrarian population — a movement explained by some writers on economics as due to the growth of gold production.

Solutions of the problem of the increased cost of living based on inefficient methods of distribution, increase in the production of gold, multiplication of middlemen, or other such causes fail. They ignore the glaring fact that we are today devoting enough acreage to support nearly 400,000,000 people to the maintenance of an animal that can work with only the fractional part of the efficiency of mechanical devices that use mineral products for their operation.

It is interesting to inquire why such relatively slow progress has been made toward more general adoption of this motor transportation. There are two important reasons. First, mental inertia or the influence of custom and habit. Second, the loss of the money now invested in horse equipment would in some cases be financially ruinous.

Mental inertia has been exemplified in the history of every new institution. When the pleasure automobile first arrived, small boys and even the adult population frequently jeered at and stoned the occupants. When Arkwright's invention of the spinning machine first came into England a large cordon of police was necessary to protect the machines from being absolutely wrecked by disgruntled workmen who thought their source of livelihood would thereby be cut off. In fifteen or twenty years perhaps present conditions will be reversed and the horse-drawn business vehicle will

be jeered at in exactly the same manner as was the first pleasure automobile.

One thing is certain, that if the auto truck can be used economically in your business, it will certainly be so used. The more quickly you accept the situation in an open-minded manner the sooner you will be convinced that you are financially benefiting yourself and society at large by employing a machine which, in an economical, humanitarian, and sanitary sense, the world needs. So will you do your share toward ushering in the horseless age, the benefits of which will be more far-reaching to civilization than any so far given us.

The transportation experts of the motor manufacturers are at your service. These investigators do not understand your business as you do, but they do know the effect of various conditions on the cost of operating auto trucks. If you will co-operate with them they will make a thorough investigation of your transportation problems and will submit accurate reports on the use of the auto truck in your business.

Information can readily be obtained on the following points concerning the manufacturers of motor trucks. There are already companies making trucks on a large scale who can point to machines of proven reliability, companies that are well-backed financially and are permanent institutions in the industry.

The companies who will not attempt to sell a large number of trucks to you regardless of the demands of your service are already numerous and increasing. Their interest in the successful operation of any truck purchased from them is second only to yours. They know they would be damaging themselves immensely more than they would you if they sold you motor trucks which you could not profitably use or which were not adapted to your business. They desire your co-operation and confidence and they deserve both.

A modern business organization must be planned with motor trucks in view for transportation and delivery service, in order to keep up with the times. Shipping stations must be provided, routes laid out, garages built, and a general equipment designed so as to make the most of motor-truck possibilities. It would be just as sensible for an architect to design a twenty-story office building of modern type, and plan to light with oil lamps instead of gas and electricity, as to lay the general plans for a large business proposition, figuring on horses for transportation instead of motor trucks.

The writer recently met a man who had bought one truck three years ago for a very large corporation. The gentleman who bought the truck is organizing a new company to take up the same line of business, and he said, "When I am ready to open my business

you can sell me a bunch of trucks; there will be no horses in my delivery system."

Four years ago the salesman's energy and the manufacturer's advertising were directed toward educating the buying public on the point of UTILITY. It was next to impossible to secure an audience with the average managers of houses handling large transportation for the purpose of talking motor trucks. Such men had not reached the point where they appreciated the utility of the truck. Fortunately this phase of education and development has practically passed. Today we find no progressive merchant who is not awake to the necessity and possibilities of motor trucks in delivery service.

But another stumbling-block has appeared, which it is necessary to overcome by means of argument and education. We refer to the question of VALUE. A purchaser will say that he can buy five or six teams for the price of one first-class, five-ton truck. Admittedly so; but in most cases the five-ton truck would do the work of the five or six teams. In fact, figures show that the average investment for a certain amount of service is almost the same for trucks as for horses. This is borne out by the equipment cost sheets of the various express companies and other large concerns using a number of motor trucks.

Let us admit, then, that the investment required

to do a certain amount of work is practically the same with the motor truck as with horse equipment, and compare the situation for a moment with other lines of business development.

The investment in any piece of machinery or other business equipment is figured on the basis of interest charge, depreciation, and cost of up-keep as against earning capacity. This is the test that will eventually be applied to the motor-truck industry. At the present time the item of first cost looms up large, but as soon as we become accustomed to thinking in motor-truck units this feature will disappear.

There are many who have predicted year after year that motor trucks would be lower in price, but this has not come to pass, as the question of quality enters into the price of any article. The public is demanding more and more in quality in motor trucks, which means that the price will be higher, rather than lower, for a really first-class article. The same condition has prevailed in the pleasure car industry, the changes in price having been very slight since the business was established on a standard basis.

We have records of hundreds of five-ton motor trucks that are earning from $30 to $50 per day gross; this means a net profit of from $20 to $30 per day to the operator. We do not know of any better paying investment. Those who are not getting this result

have not adjusted their business conditions to fit the motor truck unit. An investment in motor trucks can be utilized twenty hours per day if desired, can double up in rush seasons, and does not deteriorate or wear out when idle.

The higher plane of civilization in which we are living and operating today demands greater investment for each individual in all lines of business than ever before in the history of the world. Those who would secure the highest results must keep abreast of the times, and utilize every up-to-date idea in labor-saving machinery.

The investment per capita in hotels, warehouses, homes, schools, business offices, and public works is double what it was fifty years ago. It will probably be doubled again in the next fifty years as civilization progresses. It would not be hard to predict the result if an individual or firm would undertake to do business today on the basis of fifty years ago.

Today we do not let our children run barefoot, write our business letters by longhand, or do business in a back room on the sixth floor without an elevator or mail accommodations, and with an old dirty five-dollar desk. We are known by the company we keep, the clothes we wear, and the motor trucks we operate. This is not an age to grumble about first cost — results are the final test.

Another example of the great tractive power of the motor-truck. This 4-ton truck is pulling an 11-ton boiler. Ten horses could hardly move this boiler on a level street

This shows a 5-ton motor-truck in the service of a mining company for transporting supplies from the railroad to the scene of operation and carrying ore to the smelteries (California)

A 15-h.p. Tractor driven by a boy, pulling two road-graders

CHAPTER VII

ANALYSIS OF EXPENSE OF MOTOR TRUCK AND HORSE EQUIPMENT

MISTAKEN economy is making many business men refuse to take advantage of the profits of motor vehicle transportation. They continue to stick to their ancient delivery methods because they allow the larger initial investment required for the mechanical wagon to outweigh the big possibilities of business expansion that in nearly every case is the logical result of properly installed machine delivery.

The main issue — the reason for the appearance of the mechanical wagon among our new institutions — is likely to be overlooked. Not cost, but the larger benefits to be gained, should be the determining factor influencing a business man to replace his horses with trucks. Without these inherent benefits which so greatly overbalance its greater first cost, the motor truck would never come.

An attempt to quote figures on the cost of operating a motor truck, and to guarantee that these figures will

be exactly duplicated in the actual service of any given machine, is absurd. This a business man can clearly see if he will but analyze his individual requirements in comparison with ideal or theoretical conditions.

A lumber merchant will sometimes employ his truck for heavy-load hauls and again use it for days for carrying one-third or one-half of its rated load for very short hauls. During the latter service it will not be in motion for two hours of its rightful working day on account of waiting to be loaded or unloaded or of making many stops.

Another merchant will work his motor truck far into the night; another at times for twenty-four hours per day during periods of great activity in building industries when contracts must be met to the day or forfeits paid for failure.

Every user of a motor truck, even among those in the same kind of business, employs his vehicle under individual conditions which deviate from the ideal. Such differences make it dangerous for any company that expects to stay in business to specify either fixed charges or operating expenses on a motor truck. There are standards of comparison in that one can ascertain the kind of results attained by concerns in similar lines of business. This will serve as a safe guide in deciding whether or not it is practical to

install a truck. Again the financial problems with which he must deal can be readily discerned by the motor-truck purchaser who intends putting his transportation system on a scientific cost-accounting basis.

INVESTMENT IN TWO CLASSES

The outlay will consist of two kinds — fixed charges and operating expenses. Of fixed charges two of the factors are easily determined: interest on the investment and insurance. The owner knows what the interest on the money the truck cost him will amount to; also the total cost of the fire, accident, or liability insurance he should carry on the truck is a fixed sum. The third factor in the fixed charges, depreciation, or "amortization" as it should properly be called, is very difficult of determination.

In simple language, amortization means the wear and tear of usage and the approach of that period when the machine has served its useful or economic life and must be replaced with some other vehicle. Thus if a five-ton truck cost $4,500 and gave eight years of service, the amortization should be figured as $562.50 per year. Amortization is a factor in truck experience which is reduced to a minimum when the truck is properly cared for and driven with intelligence. Disregard of sane methods will wear out a truck in much less than ten years, the average period of use-

fulness of a well-built machine; and the amortization cost will be correspondingly increased.

Motor truck operating expenses are divided into four main items: (1) Power, either gasolene or electricity; (2) lubricants; (3) replacements of wearing parts; (4) the wages of the driver and the cost of the garage.

Of these four items there is not one which is absolutely fixed; for the large user of gasolene or oil may, and does, obtain price concessions impossible to the single truck user. Or a large user, whose delivery business is made up of such short hauls that he can more economically employ electrics, may be warranted in installing his own battery-charging plant, thus obtaining his power cheaper than the man who charges his electrics from a public battery-charging station.

The cost of lubricants, while the smallest item in the running of a power truck, is subject to comparatively wide differences in individual cases, as the driver may be careful or extravagant.

Renewal of parts is a problem that has its parallel in the case of every other mechanical institution. Low cost is achieved by care of the vehicle, frequent inspection, renewing in time one small part to save nine, and the proverbial "ounce of prevention."

Driver's wages is the largest single item in the operating cost of a power truck; and not only are

there wide divergence in driver's wages in different localities but differences due to the fact that some merchants require the drivers to be business men, soliciting business, keeping customers pleased and making collections, in addition to being skilled mechanics. A man of such varied abilities can, of course, command a larger salary than the driver who has nothing to do but get the machine to the delivery point, throw the material on the ground and leave the handling to the consignee.

Bearing these facts in mind it will be clear to every reasonable business man that it is unfair to ask the truck manufacturer to predetermine accurately the cost of running a truck per year, per mile, per trip, per 1,000 feet of material or per any other unit of power delivery.

The business man can facilitate his researches by finding out exactly what his horse and wagon system costs him. Every item of fixed and operating expenses should be analyzed in identically the same manner as the power wagon delivery system is analyzed. Probably in seventy-five per cent. of cases facts previously unknown will be brought to light.

The next calculation should be to find out how much greater a radius of delivery could be obtained for the handling of a given tonnage and number of deliveries by the substitution of the power truck for horses. To

be absolutely fair to the machine these comparisons must be made for trucks and horses operating over the same routes and under the same conditions.

With these data the merchant is in possession of facts upon which to hinge his decision. However, if the figures do show (as they rarely will) economy in sticking to horses, the argument is still in favor of machine delivery, because of the *enlarged service* practicable with motors.

Expansion is primarily the greatest benefit of the motor. With it, new territory can be cultivated for business, quite outside of the horse zone. The merchant can reach ten or fifteen customers where only five were procurable before.

The amount of money involved in motorizing a transportation business is the greatest deterrent at this time to the more general use of motorized vehicles. This is true even when the management of a business is convinced that motor transportation is more efficient and economical than horse vehicles. The most serious obstacle which confronts the builders of motor trucks who attempt to convince the general public of the investment value of this new transportation agency, is the fact that outside of a few very large, highly systematized organizations, nobody knows exactly what his horse equipment costs to maintain; and, *worst of all, nobody wants to know.*

One can go, for example, to one of the big collar and shirt-making establishments in Troy, N. Y., and be told in four-point decimals the cost per buttonhole, per stitch, or any other fractional part, of the operation of making a shirt or collar.

Ask the manager of the business, however, what it costs for cartage of the collars to the shipping point and he will tell you, "Oh, it costs such and such an amount in round figures." Cross-examine him and you may find that he is paying two or three thousand a year for the services of a consulting veterinary for his stable and yet not figuring in this item at all as a part of the cost of his horse equipment.

It is the general practise in any number of businesses to employ a watchman whose duties include the feeding, currying, or general oversight of horses belonging to the firm. These men are carried on the books as watchmen, whereas they are also stablemen or hostlers; thus part of the expense of looking after the horse or horses is not charged against them.

Again, because the cost-accounting "systems" used by individual firms vary widely and because there is no standardized cost-accounting "system" used by horse vehicle operators in keeping cost details, any attempt to standardize horse cost is almost impossible.

For instance, practically only one firm out of ten

will figure interest on the investment in the cost of their horse-delivery systems. Again, some concerns will omit important items like bedding and blankets, which we know to aggregate an appreciable sum in the course of a year, in a stable of say two hundred and fifty horses.

The difficulty of obtaining horse-cost figures of any value whatever is increased by the wide differences in the cost of grain and hay in different sections of the country. For example, horse-cost data gathered in the vicinity of New York City would be of absolutely no value in figuring the cost of an equal horse installation in say, Des Moines, Iowa, in the heart of the corn belt, where feed is cheaper.

In presenting the comparative horse and truck data in this chapter the writer desires it to be clearly understood that these figures, except where it is specifically stated otherwise, are estimates obtained by averaging a number of investigations made by competent transportation engineers to determine the advisability of motorizing the transportation departments of various firms. The motor-truck cost figures are averaged from the experiences of a number of different concerns for the class of work mentioned in the caption of each table.

It will be noted that the method of figuring horse costs is exactly the same as that used in figuring the

cost of equivalent motor installation. This, as stated, is not the method in common practise; in fact, very few horse owners figure horse costs exactly. This method is used by the author to show what, under average conditions, horse installations of various sizes really do cost.

In some instances it will be observed that the cost per ton mile for a horse transportation system is a trifle under that of a motor installation of sufficient capacity to do the same work; but the advantages in these instances in favor of the horse installation are only superficial because of the other factors in favor of the motor truck, all of which have been discussed in the previous chapter.

It has been shown that the motor truck is more than a substitute for a horse. It can do things which the horse is absolutely incapable of doing, such as completely loading and unloading with its own power. In other words, power to carry is only one of the functions of this versatile machine. The wide difference in the quality of the work which the truck can perform and for which the horse is useless has already been fully discussed; and we can only repeat that in every instance where the cost of the horse for an equivalent kind of work is less the motor truck is either being operated on a horse-unit basis or else is unfitted for the service for which it is being used.

The following shows the experience of the Marshall-Wells Hardware Company, with motor trucks:

Expense of One Light Double Team for One Month

Feed, shoeing, and veterinary	$45.00
Interest and taxes on investment	5.00
Depreciation	14.00
Driver	45.00
Painting	4.00
Repairs	5.00
Total	$118.00
Average miles per day	12
Average cost per mile	38c

Expense of One Heavy Double Team for One Month

Feed, shoeing, and veterinary	$50.00
Interest and taxes on investment	8.00
Depreciation	20.00
Driver	71.50
Repairs	10.00
Painting	5.00
Total	$164.50
Average miles per day	10
Average cost per mile	64c

Expense of Ton-and-a-Half Truck for One Month

Gasolene, oil, etc.	$20.00
Interest and taxes on investment	22.66
Depreciation	55.00
Driver	65.00
Painting	5.00
Tires and repairs	50.00
Total	$217.66
Average miles per day	35 4-10
Mileage per gallon	8
Cost per mile	23½c

Expense of 3-Ton Motor Truck for One Month

Gasolene, oil, etc.	$26.00
Interest and taxes on investment	27.00
Depreciation	67.50
Driver	65.00
Painting	5.00
Helper	52.00
Tires and repairs	50.00
Total	$292.50
Average miles per day	30½
Mileage per gallon	6
Cost per mile	36½c

The following shows maintenance cost of motor-truck versus horse equipment of the F. P. May Hardware Company, Washington, D. C.:

Maintenance

Storage, oil, and grease		$336.00
Tires		255.00
Gasolene		225.00
Operator and helper		1,092.00
Renewals and miscellaneous		50.00
Total maintenance		$1,958.00
Insurance	$112.60	
Depreciation	600.00	
Interest	160.00	872.00
Total		$2,830.60

The following are actual figures for the last twelve months (November 1, 1911, to November 1, 1912), obtained from two concerns operating a large number of horses on delivery service. These horses are of the draft type. Both of these concerns have kept track of

the cost per horse per month and have divided the expense and charged it to the following accounts:

Feed, in which are included hay, grain, and bedding, shoeing, *stabling*, under which are included fire insurance on the building and horses and the interest on the money invested in the building. No depreciation charges have been made nor has there been any charge for labor, this being charged in the Labor Account. *Feed*, where they are feeding 100 horses each day, per month per horse,	$18.20
Shoeing, where steel shoes are used done under contract for the 100 horses, per month, per horse	2.78
Stabling, which includes fire insurance and interest on building, per month, per horse	2.70
Total	$23.60
Total ($23.60), is the average per month per horse for the twelve months, making the cost per day per horse practically.	.78
Feed, in which are included hay, grain, and bedding, and shoeing. *Stabling*, under which are included fire insurance on the building and horses, also the interest on the money invested in the building. No depreciation charges have been made nor has there been any charge for labor, this being charged in the Labor Account. *Feed*, where they are feeding 100 horses each day, per horse per month	18.50
Shoeing, rubber pads being used on front feet, per month per horse	4.11
Stabling, including fire insurance and rent, per horse per month. . . .	2.42
Total	$25.03
Total ($25.03) is the average per month per horse for the twelve months, making the cost per day per horse practically.	.83

Cost of Operating Ten Single-Horse One-Ton Delivery Wagons Over a Very Extended Territory

Conditions:

20 Miles per day per wagon.

300 Working days per year.

Investment:

10 Horses @ $300	$3,000.00
10 Wagons @ 215	2,150.00
10 Sets of harness @ $55	550.00
	$5,700.00

Fixed charges:

Interest on $5,700 @ 6 per cent.		$342.00
Depreciation on Horses @ 16.67 per cent.	$500.00	
" " Wagons @ 33.3 per cent.	716.67	
" " Harness @ 33.3 per cent.	183.33	1,400.00
Stable rent . . . . . . $75 per month.		
Gas . . . . 5 " "		
Insurance . . . . . . 15 " "		
Water . . . . 5 " "		
$100 " "		1,200.00
Veterinary		80.00
10 Drivers @ $2 per day		6,000.00
		$9,022.00

Variable charges:

Maintenance wagons $500		
" harness 150		$650.00
Feed		2,100.00
Shoeing		300.00
Total cost per annum		$12,072.00
" " " day		40.24
" " " ton mile		0.201

Cost of Operating Four Two-Ton Motor Trucks in the Same Service

Conditions:

40 Miles per day per truck. 300 Working days per year.

Investment:

4 2-Ton Chassis @ $3,000	$12,000.00
4 Delivery Bodies @ 250	1,000.00
	$13,000.00

Fixed charges:

Interest on $13,000 @ 6 per cent.	$780.00
Fixed depreciation @ 10 per cent. on investment, exclusive of tires	1,193.04
Insurance @ 2¼ per cent. of value	234.00
Garage @ $15 per month per truck	720.00
4 Drivers @ $18 per week	3,744.00
Total fixed charges	$6,671.04

Operating charges:

Depreciation @ 2 per cent. on $11,930.40	$238.61
Maintenance @ 1.75 cents per mile	840.00
Tires @ 2 cents per mile	960.00
Gasolene @ 1.5 cents per mile	720.00
Oil and Grease @ 0.5 cent per mile	240.00
Total cost per annum	$9,669.65
" " " day	32.23
" " " ton mile	0.101

THE COMMONWEALTH EDISON COMPANY

Herewith is presented the results of an accurate examination of the books of a large company owning and operating one of the largest fleets of horse-drawn wagons in Chicago:

Operating one double wagon one day, one team, without helper:

2 Horses	$1.9688
1 Set harness	0.1394
1 Double wagon	0.4004
1 Driver	2.6666
Wheel tax	0.0324
Accident insurance	0.0370
Rent, light, heat	0.7603
	$6.0049

Cost per mile $0.40 (15 miles)

Operating one double wagon one day, two teams, without helper:

4 Horses	$3.9376
1 Set harness	0.1394
1 Double wagon	0.4004
1 Driver	2.6666
Wheel tax	0.0324
Accident insurance	0.0370
Rents, light, heat	1.1237
	$8.3371

Cost per mile $0.41 (20 miles)

The items entering into these calculations are as follows:

Cost of one horse (value $150) per day:

Feed	$0.4870
Stable labor	0.1951
Shoeing	0.1106
Veterinary and medicine	0.0209
Stable, general expenses	0.0363
Insurance	0.0079
Interest	0.0292
Depreciation	0.0974
	$0.9844

Harness ($65) double set, per day:

Repairs	$0.0810
Insurance	0.0034
Depreciation	0.0424
Interest	0.0126
	$0.1394

Double wagon ($250) per day:

Up-keep	$0.1763
Insurance	0.0131
Depreciation	0.1623
Interest	0.0487
	$0.4004

Suburban delivery service with eight two-horse teams in active service. Teams average twenty miles per day each and cover one hundred and sixty miles of route. Each team rests every fourth day.

Investment:

20 Horses @ \$300	\$6,000.00
9 Sets double harness @ \$90	810.00
9 3-Ton wagons @ \$7.00	6,300.00
	\$13,110.00

Fixed charges:

Interest on \$6,550 @ 6 per cent.	\$393.30
Depreciation horses @ $16\frac{2}{3}$ per cent.	1,000.20
" wagons @ 25 " "	1,575.00
" harness @ $33\frac{1}{3}$ " "	270.00
Insurance-fire ($2\frac{1}{4}$ per cent. on horses, wagons, harness)	294.98
Veterinary	100.00
Maintenance wagons	450.00
" harness	135.00
Shoeing	600.00
Feed	4,200.00
Stable expense	2,000.00
8 Drivers @ \$2.00 per day (300 days)	4,800.00
8 Helpers @ \$1.50 " " " "	3,600.00
Total cost per year	\$19,418.48
" " " day	64.73
Cost per day per team operating	8.09

Suburban delivery service having four three-ton trucks in active service, making forty miles per day each, thus covering one hundred and sixty miles of route:

Investment:

5 3-Ton mack chassis @ \$3,750	\$18,750.00
5 Furniture bodies @ 450	2,250.00
	\$21,000.00

Fixed charges:

Interest on $11,500 @ 5 per cent		$690.00
Fire insurance 2¼ per cent. on 80 per cent. of one-half value		189.00
Fixed depreciation @ 10 per cent. on $19,271.50		1,927.15
Wages of 4 drivers @ $20.00 per week		4,160.00
" " 5 helpers @ 1.50 " day		1,800.00
Garage on 5 cars @ 20.00 " month		1,200.00
Total fixed charges		$9,966.15

Operating charges:

Maintenance @ 3 cents per mile		1,440.00
Tires @ 4 " " " 4 by 12,000 miles		1,920.00
Gasolene @ 2.5 " " "		1,200.00
Oil and grease @ 75 cents		360.00
Total cost per year		$14,886.15
" " " day		. 49.62
Total cost per day per truck in operation		12.40
Cost of horse equipment per day	$64.73	
" " motor " " "	49.62	
Saving by motor equipment per day	$15.11	
" " " " " year	$4,632.33	

Cost of operating five horse-drawn two and one-half-ton delivery wagons in general delivery service:

Conditions:

20 Miles per day per wagon.
300 Working days per year.

Investment:

12 Horses @ $300	$3,600.00
5 Wagons @ 450	2,250.00
5 Sets double harness @ $60	300.00
Blankets, etc.	50.00
	$6,200.00

Fixed charges:

Interest on $6200 @ 6 per cent	$3,720.00
Depreciation on horses @ 15 per cent	540.00
" " wagons @ 10 " "	225.00
" " harness, etc., @ 5 per cent	17.50
	$4,502.50

Tractors are used in Dixie for logging as well as farming

Oil Tractor with automatic steering guide and automatic lift-plow. An outfit that needs but one man and needs him only at the furrow-end

Tractors are being built by the acre and shipped by the trainload to the south, the west, and the Canadian prairies

Stable rent	$150 per month.		
Gas	15 " "		
Insurance	15 " "		
Water	10 " "		
	$190 per month,		$2,280.00
Veterinary			880.00
5 Drivers @ $20 per day			3,000.00
Total fixed charges			$10,662.50
Maintenance of wagons		$250	
" " harness		75	
		$320	320.00
Feed @ $210 per horse			2,520.00
Shoeing @ 40 " "			480.00
Total cost per annum			$13,982.50
" " " day			46.61
" " " mile (for 100 miles)			0.466

Cost of operating two five-ton auto trucks in general delivery service:

Conditions:

30 Miles per day.
300 Working days per year.

Investment:

2 5-Ton chassis with equipment	$9,600.00
2 Appropriate bodies	600.00
	$10,200.00

Fixed charges:

Interest on $5,100 @ 6 per cent.	$306.00
Fire insurance 2¼ per cent. on 80 per cent. of one-half value	92.80
Fixed depreciation (exclusive of tires) on $9,316 @ 10 per cent.	931.60
Wages @ $40 per week	2,080.00
Garage @ 40 " month	480.00
Total fixed charges	$3,889.40

Operating charges:

Depreciation @ 1 per cent. for 1,000 miles for all yearly mileage over 10,000.		
Maintenance @ 4 cents per mile		720.00
Tires @ 6 " " "		1,080.00
Gasolene @ 3.5 " " "		630.00
Oil and grease @ 1¼ " " "		224.00
Total cost per annum (2 trucks)		$6,543.40
" " " day		21.80
" " " mile		0.363

Conditions:

50 Miles a day.
300 Working days per year.

Total cost per annum (2 trucks)	$8,780.20
" " " day	29.27
" " " mile	0.292

Cost of operating forty-five double teams hauling four-ton trucks; and covering twenty-five miles per day each at a total of 1,125 truck miles per day:

Investment:

100 Horses @ $300	$30,000.00
50 Wagons @ 250	12,500.00
50 Sets of harness @ $60	30,000.00
50 Sets of blankets, etc., @ $25	1,250.00
	$46,750.00

Fixed charges:

Investment on $46,750 @ 5 per cent	$2,337.50
Depreciation on horses @ 20 per cent	6,000.00
" " wagons, harness, etc., @ 10 per cent.	1,675.00
Stable charges, including rent, insurance, heat, light, and water	15,000.00
Labor, 7 stable hands @ $9 per week	3,276.00
" day foreman @ 20 " "	1,040.00
" night foreman @ 16 " "	832.00
45 Drivers @ $2 per day	27,000.00
	$57,160.50

Variable charges:

Maintenance of wagons @ $50 each	$2,500.00
" " harness @ 15 "	750.00
Feed @ $18.30 per month per horse	21,960.00
Shoeing, steel shoes by contract @ $2.78 per horse, per month	3,336.00
Total cost per year	$85,706.50
" " " day (300 days)	285.69
" " " truck mile	0.254
" " " ton mile (loaded one-half distance)	0.127

Cost of operating twenty-eight two-ton motor trucks running forty miles per day, each at a total af 1,120 truck miles per day:

Investment:

32 2-Ton chassis @ $3,000	$96,000.00
32 2-Ton delivery bodies @ $250	8,000.00
	$104,000.00

Fixed charges:

Interest on $104,00 @ 5 per cent.	$5,200.00
Depreciation @ 10 per cent. on $95,040 (exclusive of tires)	9,540.00
Insurance 2 per cent. on 80 per cent. of value	1,664.00
Garage @ $20 per month	7,680.00
28 Drivers @ $20 per week	29,120.00

Operating charges:

Additional depreciation @ 1 per cent. per 1,000 miles in excess of 10,000 miles per year 0.5 per cent.	$475.20
Maintenance @ .025 per mile	8,400.00
Tires @ .035 " "	11,760.00
Gasolene @ .025 " "	8,400.00
Oil and grease @ .0075 " "	2,520.00
Total cost per year	$88,743.20
" " " day	295.81
" " " truck mile	0.264
" " " ton mile (loaded one-half distance)	0.264

Experience of Stix, Baer & Fuller Company, St. Louis, with motor transportation.

This is a large retail furniture establishment which makes long, heavy hauls. It uses two 3–ton, five 2–ton, and three 1½–ton trucks. The superintendent of this establishment states his experience with motor trucks as follows:

"Figuring the exact cost of our trucks, taking twenty-five per cent. off annually for depreciation, and counting salaries of drivers, insurance, rent, gasolene, oil, and repairs, we have found that the cost per package when hauled by trucks is from thirty to fifty per cent. less than the cost of hauling over the same route by horses and wagons. The exact figures as we found them were that furniture costs us 24⅓ cents per piece per truck hauling and 35 cents per piece by horses. Bulky goods cost us 10½ cents per piece by motor-truck delivery and 14¾ cents per piece by wagon. Our trucks make two trips a day running from 7.30 A.M. to 7 P.M. In December, 1911, one of our light wagons carried 6,527 packages, made 5,891 stops, and went 1,185 miles on 259 gallons of gasolene and 23 quarts of oil. Our drivers were handling horses and wagons before they were put on the machines. The trucks have surely made money for us."

Experience of Capital City Lumber Company, of Hartford, Conn.

This company states that their 5-ton truck replaced 5½ teams and that the truck delivers lumber at 36 cents per thousand feet while the teams cost 75 cents per thousand feet, or more than twice as much. They analyze the cost as follows:

	Truck	Team
Total investment — with equipment	$5,362.12	$1,510.00
Total expense per day	15.26	5.63
Average mileage per day	42.5	15
Average round trip haul — miles	5	5
Average number trips per day	8.5	3
Average load, dressed lumber	5,000 feet	3,500 feet
Average weight per load	5 tons	2.5 tons
Carrying total per day	42,500 feet	7,500 feet
Total expense per 1,000 feet	36 cents	75 cents

The truck is equipped with a roller body, and has as an accessory, a small four-wheel loading wagon for gathering lumber about the yard and having the load ready for the truck. By actual timing it has been found that it takes three minutes to transfer the lumber to the truck, and two minutes to unload, without damage of any kind to the lumber.

Cost of Operating Single and Double Team in Boston. Compiled by a Firm of Prominent Boston Accountants.

BLACK & BLACK (Using 160 horses)

Drivers, pay per day	$2.00	$2.50
Feed per working horse per day	.90	1.80
Rent and stable expenses per horse per day	.31	.62
Shoeing and small repairs, per horse per day	.19	.38
Claims, accidents, tolls, etc.	.18	.36
Foreman's and lumper pro rata	.18	.36
Other helpers per horse per day	.20	.40
Repairs, harnesses, and painting	.13	.26
Manager's and superintendent's salaries per day	.10	.20
Office rent, telephones, and clerks	.31	.62
Miscellaneous, veterinary, etc.	.24	.48
Fire and accident insurance	.08	.16
Depreciation for renewals of horses	.20	.40
	$5.02	$8.54

Actual cost figures of operation of three-ton motor truck known as Automobile No. 31 as carried on the books of the New York Telephone Company. Figures supplied by Mr. A. W. Allen, Supt. of Buildings and Supplies, May 20, 1912.

Period of use June 10, 1911, to February 29, 1912	
Number of days in actual use	189
Average number of miles per day	32.55
Total mileage for period	6,155
Investment:	
Chassis with body	$4,017.00
Fixed charges:	
Interest @ 6 per cent.	$241.02
Insurance and supervision	11.50
Depreciation @ 20 per cent	582.40
Wages	679.74
Garage	227.55
Total fixed charges	$1,742.21

Operating charges:

Maintenance	@ 6.62 cents per mile	. . . .	$407.99
Tires	@ 3 " " "	. . . .	184.65
Gasolene	@ 3.43 " " "	. . . .	211.13
Oil and grease	@ 2.05 " " "	. . . .	126.54
Total cost for eight months, twenty days			$2,672.52
Cost per day running		. . . .	14.14

RECORD OF TON-AND-A-HALF MOTOR TRUCK SECOND YEAR OF SERVICE

THE FAIR, CHICAGO

	Total	Daily Average
Gasolene	$219.22	.71½
Oil	47.47	.15½
Electric current	1.20	.0⅜
Batteries	2.54	.0⅚
Grease	2.57	.0⅚
Carbite	2.08	.0⅔
Other supplies	9.46	.03$\frac{1}{12}$
Tires	391.02	1.27⅝
Repairs to machine (routine)	24.65	.08
Repairs to machine (accident)	32.50	.10⅝
Repairs to body, etc. (routine)	73.14	.23⅞
Repairs to body, etc. (accident)	17.75	.05
Added equipment	19.53	.06⅜
Salary	919.50	3.00
City and state licenses	34.68	.11⅜
Insurance	196.92	.64¼
Depreciation @ ½ per cent per year	999.96	3.26¼

NEW YORK TELEPHONE COMPANY PLANT DEPARTMENT

Cost of Operating 5-Ton Gasolene Motor Truck for Four Years, August 1907 to August 1911

	Wages	Garage	Gasolene		Oil		Tires	Supplies & Reprs.	Monthly Cost	No. Wkg. Days	Cost of Day	Monthly Mileage	Av. daily Mileage	Cost per Mile	Cost of Gasolene per Mile	Cost of Oil per Mile
			Gal.	Cost	Gal.	Cost										
Average per month for first year	$112.57	$29.75	184	$38.59	19	$15.76	$46.10	$30.91	$273.67	26	$10.86	503¾	19.43	$0.5636	$0.0767	$0.0309
Average per month for second year	110.75	30.08	163	32.70	19	5.80	43.65	34.26	257.22	23	11.14	436¾	18.91	.5895	.0749	.0133
Average per month for third year	120.11	38.69	164	31.27	22	6.43	36.27	68.59	301.36	25	11.97	436½	17.34	.6905	.0716	.0147
Average per month for fourth year	108.73	35.25	186	36.36	21	6.51	68.43	79.20	334.48	24	15.38	486¾	20.3	.7575	.1098	.0155
Average per month for four years	113.04	33.44	174¼	34.73	20¼	8.625	48.61¼	53.24	291.68¼	24½	12.44	465.91	19	.6503	.0843	.0186

Average cost per day for fourth year (285 working days) including interest, insurance, and depreciation $14.26
Average cost per day for four years (1175 working days) including interest, insurance, and depreciation $14.11

Interest........6 per cent. Insurance........8 per cent. Depreciation........12½ per cent.

The small daily mileage of this truck is due to the fact that it is equipped with a winch, geared to the motor, which is used for hauling heavy cables through street conduits by motor power when truck is standing still.

Average Cost Per Day

Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
10.26	10.28	9.76	9.60	9.27	8.94	9.84	9.84	10.92	9.08	9.37	10.19
Days in service											
27	25	26	26	25	27	25	25	24½	25	26	25
Days in shop											
0	0	0	0	0	0	1	1	½	0	0	0
Days in reserve											
0	0	0	0	0	0	0	0	0	0	0	0
Odometer reading											
1,425	2,800	4,334	5,738	7,138	8,623	124	1,499	2,945	4,420	5,827	7,227
Mileage											
1,425	1,375	1,534	1,404	1,400	1,485	1,500	1,375	1,446	1,475	1,407	1,400
Miles average per day											
53	55	59	54	56	55	60	55	57	59	54	56

The figures given below are furnished by a large public service transportation company which does not wish its name published.

Heavy Service

	No. of Horses	No. of Machines
	75	44
	30	11
	16	5
	121	60
Investment		
	Horse	Machine
	$94,551	$166,746
	26,615	36,584
	7,975	17,784
	$129,141	$221,114

Expense

Horse	Machine
$136,746	$113,187
44,198	28,378
15,587	11,557
$196,531	$153,122

Annual Saving	Per Cent on Earnings on the Investment	Per Cent Saved over Horse Expense
$23,660	14.2	17.5
15,819	43.2	35.7
4,030	22.6	25.8
$43,509	19.6	22.0

Medium Service

No. of Horses	No. of Machines
35	31
17	10
33	20
21	14
48	37
154	112

Investment

Horse	Machine
$36,485	$83,003
14,300	23,500
21,848	51,126
39,778	46,170
54,095	75,598
$166,506	$279,397

Expense

Horse	Machine
$91,530	$70,663
29,074	18,972
50,249	38,444
41,593	31,802
115,284	75,745
$327,730	$235,626

Annual Saving	Per Cent in Earnings on the Investment	Per Cent Saved over Horse Expense
$20,867	25.0	23.0
10,102	42.9	34.0
11,805	23.0	23.3
9,791	21.2	23.5
39,539	52.3	34.2
$92,104	32.9	28.0

The user of a 1-ton gasolene truck in light metal-ware manufacturing business submits the following comparison between horses and trucks from a year's experience in which he has kept detailed records:

Investment, horses:		
Seven horses @ $350 (based on one extra) . . .	$1,750.00	
Three wagons @ 275	825.00	
Three double harnesses @ $65	195.00	
Seven blankets @ $2.00.	14.00	
Seven halters @ 1.25	8.75	
		$2,792.75
Investment, truck:		
Model	$2,100.00	
Express body and top, plus freight	250.00	2,350.00
		$442.75

Saving on Investment

Operation, horses:		
Three drivers @ $70 a month	$2,520.00	
Stable, feed, veterinary, etc.	2,268.00	
Repairs and painting wagons	1,335.00	
Repairs, harnesses	24.00	
Interest on investment @ 6 per cent. . . .	167.57	
Depreciation on horses @ 16.6 " "	291.66	
" " equipment @ 15 " "	156.41	5,562.64
Operation, truck:		
Driver @ $75 a month	$900.00	
Helper @ 60 " "	720.00	
Gasolene, five gallons a day @ 14c	210.00	
Oil and grease	40.00	
Repairs and painting	300.00	
Oil for lamps and incidentals	20.00	
Tire maintenance	200.00	
Garage	72.00	
Interest on investment @ 6 per cent	141.00	
Depreciation @ 16.6 per cent	391.66	2,994.66
		$2,567.98

Operating Cost of Electric Motor Trucks

The following guaranteed figures are used by a large electric vehicle company in their estimates of the costs of operation of their various sized trucks. These figures include all the items mentioned in the cost of operation of gasolene trucks with the exception of tire maintenance.

Costs of operation per day and per year of three

hundred working days, including fixed charges, replacement charges, garage charges, and driver. Depreciation figures at ten per cent per annum and included in fixed charges (lead battery):

Capacity	Cost per Day	Cost per Year
750-pound wagon	$6.301	$1,890.05
1,000 " "	6.857	2,056.80
2,000 " "	7.659	2,297.80
2-ton truck	8.852	2,655.85
3½ " "	10.338	3,101.60
5 " "	11.603	3,481.00

CHAPTER VIII

THE INVALUABLE TRACTOR

ONE third of the people of the United States, and by far the largest single class of wealth producers, live in the rural districts. National prosperity is dependent on the success of their labors.

Any factor that influences their lives in any marked degree is of importance in history. Anything that affects their physical and mental development, the ownership of their land, the quality, volume, or price of their products, methods of production and marketing, or the financing of their business, is extremely significant from the historian's standpoint.

Farm machinery has vitally affected this class in the matters above enumerated. In fact, the entire history of American agriculture is divided into periods based entirely upon the development of farm machinery.

With respect to the character of implements and machinery on farms, there are three fairly distinct periods. The first is the era of hand methods, continuing until well toward the middle of the nineteenth century. In fact, up until 1850, the wagon, the cart,

and the cotton gin were practically the only implements or machines which did not belong to hand methods of production.

The second great period was the era of transition from hand to machine methods, continuing from 1850 to about 1870. At the latter date practically all of our modern machines were in the field in some crude form, and the idea of superseding hand methods by machinery had firmly fixed itself upon the mind of the average farmer.

From 1870 until the close of the century improvement in all classes of machinery was marked and this might be called the *era of farm machinery*. During this era scientific breeding, based on the introduction of improved foreign stock, improved the efficiency of the average farm horse at least twenty-five per cent. During the same time the number of horses and other work animals used on farms for each farm laborer also increased about fourfold.

In view of what will be said later regarding the influence of power on agriculture, it is significant that in the same time, and corresponding to the number and efficiency of horses, the farm products per farm laborer increased about *five times*.

By reason of these improvements in machinery and the increase in animal power at the disposal of the laborer, the farmer was relieved of drudgery and given

time to study his work. His hours of service were made shorter and his mental faculties stimulated. He became a more efficient worker, a broader man, and a better citizen. The quality and yield of his products were improved by confining crop operations within those periods each season when the most favorable conditions prevail.

The farm machine has greatly decreased the cost of production and increased profits. It has greatly reduced the proportion of laborers required to produce the nation's food supply, leaving it free to aid in industrial development along other lines.

For example, four farm families in 1800 barely supported one in town, while two in the country now support three in town and still leave a balance for export, in spite of decreasing surplus.

This change has thrown upon the cities the burden of providing work for the increased army of workers, and in turn makes it necessary for each farm laborer to produce a greater and greater surplus of food above the needs of his own family. The introduction of machinery has increased the skill required of the farm hand laborer, so that the ordinary city laborer will not make good on the farm.

Most important of all, perhaps, this increase in the use of machinery has enlarged the investment necessary for properly organizing a farm. This and the constant

Oil pull tractor hauling ore in the Rocky Mountains

Tractor in New Mexico pumping for irrigation

rise in the price of land have made it more difficult for persons of small capital to engage in farming.

All of these great changes had actually taken place before the opening of the last great epoch in American agriculture — the age of mechanical power on the farm. Up to the present time we have discussed the effect of farm machinery when drawn by animal power — the same power that had been used since the days of the first plow. While farm machinery had been wonderfully advanced, the power had remained the same for centuries. Only in the last decade has agriculture begun a widespread shift to mechanical power, the factor which has so wonderfully developed other industries.

Power shapes our modern world. The thought of power is fascinating to the human mind. Around the struggle for one sort of power or another have centered all the mightiest struggles of history. Around the power of the engine to do useful work have grown the greatest industrial empires ever known.

The farm tractor and the stationary farm engine have brought mechanical power to the farm. The latter replaces the farmer's own muscle and lightens his work. The tractor, which is replacing the farmer's greatest source of power, is the great history-making machine of the twentieth century. The reorganization of the farm which must take place will surely hinge on the solution of the power problem.

The human race uses power for the three great fundamental needs: Tilling the soil to produce raw materials for food and clothing, or agriculture; changing the shape of these materials so as to adapt them for human use, or manufacturing; and carrying these materials from place to place, or transportation.

Since Watt's invention of the steam-engine, mechanical power in the factory has centered production, drawn the processes of manufacture away from the home, and taken with them much of the best blood and capital. They are now in turn sending back machinery and engines to the country to take the place of the laborers they drafted.

The great steam-driven factories are producing at an enormously cheaper rate, and on a much higher plane of efficiency, than was possible by the old homespun and tallow-candle methods of our grandfathers. Fulton and Stephenson applied mechanical power to the steamship and the steam railway and today a steam-driven commerce binds the nations together.

Agriculture, the fundamental industry, has lagged far behind, and it is only with the occupation of practically all of our naturally productive land that the problem of cheaper production has become uppermost.

The problem of applying mechanical power to the soil is vastly different from that of collecting raw materials for use in a central power-driven factory.

The farm power plant must be capable of going from place to place and doing its work wherever found.

Again, the limitations of topography, climate, and soil make the mechanical problem of supplying an efficient farm tractor much greater than that of making a stationary engine for the factory.

The farmer, too, is conservative, and has been slower to adopt changes than the manufacturer involved in the whirl of modern competition. The farmer, however, must now adopt mechanical power on a scale which compares with that of the other two great industries, or else fail to meet the demand for food with profit to himself.

The broad evolution in farm methods may be illustrated by that of the plow, the fundamental farm implement. From the crooked stick, changes were slow until late in the nineteenth century, and up until a generation ago the walking plow was almost universal.

When the farmer began using animal power in larger quantities changes were rapid. The walking plow has now all but disappeared from common use in our Western States, and for a generation the farmer has ridden the sulky plow, or the gang, using more animals and less human labor.

From the gang plow to the small tractor is the next step in size, although the largest tractors came first in point of time. Tractors capable of pulling four to six

plows are now coming rapidly into use in the corn belt, while the larger ones with from eight to fourteen plows find ready sale in the Northwest.

It seemed at one time as though the limit had been reached. Engines had attained the greatest size consistent with safe and economical transport. But just as two, three or four horses succeeded one, so multiple tractor outfits are already coming.

At a recent demonstration at Purdue University three 30-horse-power kerosene engines hitched to one giant plow of fifty bottoms broke all known records for plowing. This twentieth-century monster broke out a strip nearly sixty feet wide at each trip, plowing at a rate of an acre every four and one-quarter minutes. Four men, three engineers, and a plowman, men of skill and keen intellect rather than plodding clodhoppers, handled the valves and levers of an outfit that equaled the work of fifty men with sulky plows and a hundred and fifty straining horses.

The tractor is compelling the change to mechanical power, the greatest change that has come to agriculture since the savage first hitched a forked stick to the horns of his bull and declared man free from the curse of Adam.

The horse works only one hour in nine on an average for the year; but he must be kept warm and sheltered,

must be fed and watered three times a day, whether used or not. During the winter his only work is the little that is necessary to keep him in condition. He must be maintained for twelve months to be ready for the work of four. He depreciates in idleness and is subject to disease and accident.

The feed of a work horse costs \$55 to \$60 a year and other items bring the total to \$100, or more than 10 cents for each hour of work. The cost of buildings has advanced and the cost of shelter for the horse and his feed is becoming prohibitive.

The tractor does not require attention when not at work. Thirty million work animals, each taking twenty-seven minutes of a man's time every day, mean an enormous waste of human energy. The time spent annually in caring for one horse will keep in perfect condition a tractor with the power of thirty horses.

The tractor will endure hard work twenty-four hours a day instead of six and outlive the average horse in hours of service. Its fuel is much more concentrated than food for the horse, and a tractor with a year's fuel supply can be sheltered in a tenth of the space required for horses of equal power and their feed.

The animal, especially in cities, is a constant menace to public health. Both on the streets and on the farm the connection of its refuse with the disease-breeding

fly is becoming recognized. Due to our wasteful methods of handling natural fertilizers, our work teams constitute a serious drain upon our soil fertility.

Feed for our work animals costs one and a quarter billions per year, equal to the total income of two million average families. The crops from five to eight acres are withheld from supplying human needs by the necessity of maintaining each animal.

Farm labor is constantly growing scarcer, and where five men would be needed to drive twenty-five horses hitched to gang plows, one man on a tractor, with an assistant on the plow behind, will accomplish as much work. The tractor will handle every operation on the grain farm from soil to market. It will plow, disc, sow, harrow, harvest, thresh, and haul the grain. It will combine two or more operations with a great saving in power.

By its rapid work the tractor renders the farmer less dependent on Providence and insures greater yields by giving him the upper hand of unfavorable conditions. In the corn belt it enables deeper plowing to be done without the great excess of horse-flesh which costs so much for maintenance throughout the idle months of the year.

The coming of abundant power to the farm means enormous things in the way of better farming and cheaper farming.

It enables larger areas to be cultivated as well as before, and the same areas to be cultivated much better. Either way, it increases the effectiveness of the farmer and enables him to produce at a much lower cost of operation expressed in percentage of the total crop.

Mechanical power on the farm saves wages, perhaps, rather than money. The tractor and its accompanying machinery represents an investment which requires capital. Labor is a commodity which can be paid for piecemeal as used, but the machine must be paid for all at once or within a short time.

The machine is making history, because for wages it substitutes interest on investment. The man with only his labor as capital is coming to the same point on the farm as he has come elsewhere. He cannot compete with machines that represent money and a lower cost of production. It is only natural for him to oppose the introduction of such equipment.

Yet the small farmer cannot stop the coming of large machinery and mechanical power. He should have no wish to do so, since machinery means cheaper production and a saving of human energy, which is our most precious possession. We are, however, vitally interested in knowing who will buy the machine, since the men whose money buys the machine will unquestionably have the direction of its operations.

The question arises as to the fate of the small farmer.

It has long been preached as fundamental that the prosperity and continued welfare of the country depends on the success of a large body of farmers on small, independent farms.

The cry has been that the big farmer was a detriment to good and profitable farming; that the big farmer was always "land poor" because he could not cultivate his acres with a high degree of efficiency. "The little farm well tilled" has been the ideal, and with former equipment and power this was undoubtedly well founded.

Now, however, a new mechanical factor has entered, and the big farm can be handled on a basis of quality. Colleges, other public institutions, and even city business houses are turning out business managers capable of keeping big farms up to a high standard. Intensive farming on a large scale is made possible by modern men and machines.

Since mechanical power is the thing that has brought about these changes, it is urged that the small farmer be given a tractor adapted to the size of his present holdings.

However, the small tractor costs proportionally more to buy and to operate. It costs more to buy because the building and selling cost is not reduced in proportion to the power developed. It has serious mechanical disadvantages which do not occur in the tractor pulling six or more plows.

It is significant that Europe, which has long been up against these problems that are now looming large in America, has never solved the problem of the small tractor. The small tractor, if developed, may stem the tide for a time, but it will give way to the larger outfit, just as the single horse gave way to the four-horse team.

This outcome is, of course, subject to natural limitations, but wherever the large tractor can be used the smaller will yield, just as water wheels have disappeared from all but isolated neighborhood factories, and sailing craft from all but the slowest of routes.

If the large tractor and the large farm are coming, then what of the small farmer? Will he be driven out of existence, or will he protect himself by learning to co-operate with his neighbor? One or the other alternative seems inevitable. Economy of production points to the use of the largest power unit and the largest machine that the natural features and type of farming will allow. This, then, will mean that the size of the neighborhood co-operative association will be based upon the size of the largest machine that can be used upon the combined farms.

Considerable reconstructive work may sometimes be necessary in order to make these improvements possible. Many a modern factory or office building is torn down after a few years to make room for a bigger and better one. The roads, buildings, and fences established when

small power units were used may have to be removed at considerable cost in order to adapt farms to more efficient methods of production.

If, after reconstruction, such farming cannot be done at a profit in competition with more favored sections, the system of farming must be changed. Skilful management will decide upon such questions. The individual cannot call in the services of college-trained experts to advise him, as a co-operative body can, but the time will come when every operation from plowing to marketing must be under the eye of a well-equipped supervisor.

The farmer has no more right to be independent in the present sense than the laborer in the city. Some day he must be content to be one of the rank and file, working with his neighbors under the direction of those best equipped, if he is to continue his work at a profit.

In actual practise we now have numerous co-operative associations where the management is in the hands of well-paid experts. If the farmer cannot supply the capital necessary to organize production on a proper basis he must adopt the city's policy and employ money — *borrowed* money.

The individual citizen in town could not carry out large public improvements; but working in common with his neighbors he has drawn away capital from the farm and made it pay a profit well above the interest.

The city is thus able to spend $35,000 per mile for streets, where in some cases only $50 per mile is allowed for country roads.

These investments pay, but unless farmers work together they cannot force the use of their share of the country's capital. Thus one of the greatest questions now before our national government, that of legislation making for better credit terms for the farmer, is raised by farm machinery and the tractor.

Co-operation, real co-operation, is the solution of many difficulties. Co-operation has proved a success in many localities where farms are small, especially where fruit and vegetables are marketed at a considerable distance. In the sections of large farms and local markets this movement has not grown as rapidly as it should. Farms are growing larger, however, in the Central States, and are remaining large in new sections where they have not already been parceled out.

Mechanical power is coming in rapidly to work these greater farms. It is making co-operation necessary. The old-time threshing ring is being duplicated many times, but the neighborhood tractor does far more than the threshing engine ever had to do. The farmer who persists in his "independence" and small-scale production for another decade invites absolute failure.

Agriculture is finally committed to mechanical power. The year 1912 probably saw nearly two million mechani-

cal horse power sold to our farmers. The great multiple-engine and 50-plow outfit at Purdue University has shown that mechanical power may very possibly be applied to agriculture on the scale of the largest ocean liner's engines or the turbines of the central power plant, if farming should ever require that scale of operations.

If the small farmer does not co-operate to equip his farm with a share of the most efficient cost-saving machinery, he has no basis for legitimate objection if capital takes the initiative in economical production and reduces him to the wage-earning class. For, after all, the real purpose of agriculture is not the enrichment of the man who tills the soil, but the providing of a hungry world with food.

Farm machinery in general has made history because it has profoundly affected the work and welfare of the farm laborer. The tractor is making history because it comes to solve a problem at a time when the demand for breadstuffs has overtaken the possible supply under former methods of production. New countries have adopted higher food standards. The world is pressing on the limits of production and needs for the human race the one acre out of every four that until now has been devoted to the feeding of droves of idle animals.

The machine furnishes power to cultivate new acres and to make older ones produce more abundantly. It

keeps down costs and insures adequate production. Moreover, it is hastening to a decision the issue between men and capital in the last great field of industry.

The tractor then is more than a machine. It is a solution of a great world problem — hunger. And it is making history because it is making agriculture over.

Some one paraphrasing a popular advertisement, has written of a modern kerosene tractor a boast that is significant in its truth and prophecy. It needs little imagination to conceive that the coming of the tractor marks the last and greatest epoch of all.

I am the Tractor

I am the tractor, born of the spirit of man. My ribs are of iron and my sinews of steel. I breathe the vital air of heaven. I feed on the oil of the earth. Swift lightning courses my nerves of burnished copper. Fire and power awake at their flash in my bosom and drive my sturdy legs to action.

I serve the children of men. At their bidding I become a thing of life, to draw the plow. I lift the yoke from their shoulders and bear the heaviest burden of their toil. By day and by night, unresting, I upturn the hidden depths. Hand in hand with sun and frost and rain, I crumble the wild plain to fertile dust.

I sow. I reap and glean. I winnow corn from the

chaff and fetch it to give new life. I bring the dumb beast rest. I bring to the toiler his daily loaf. I bring happy occupation to hosts on railway and sea, in the mill and the factory. I am today's beast of burden. I am the hope of food and life for tomorrow's millions. I am the tractor, born for labor unending.

CHAPTER IX

THE INEVITABLE TRACTOR

A SAVAGE sharpened a twisted stick and began to stir the soil in imitation of a wild boar's snout. In some lands, even today, people cling to the crooked stick. First the women, then the oxen, drew the forked stick plow. The camel, the elephant, and every other beast of burden has done its share toward tilling the soil.

Think how slowly the art of plowing has progressed through the centuries! Only a hundred years ago the Yankee plow was a crude back-breaking affair of wood, and a generation after that Newbold's cast-iron plow was held to poison the soil, injure its fertility and promote the growth of weeds.

The single ox still drags his weary way along the furrow of many a Southern cotton patch; and out on the prairie homestead "Buck" and "Bright" with a modern walking plow show that it is useless to talk of utterly supplanting any form of power that has ever proved efficient.

The walking plow has disappeared from even the

classic plowing matches of Illinois, but many a farmer in the East clings to it and three stout horses. Yet for nearly a quarter-century the Western plowman has ridden the sulky and shifted to the staggered furrow wheel the strain of holding the plow to line.

Gaining capacity, in former days, meant multiplying the number of outfits in the field, an idea which was easily defeated, however, by putting the slowest team in front. Soon after the sulky came the gang plow and today its name is legion. The disc plow lagged far behind the moldboard in appearing; but after its establishment on a solid basis, less than twenty years ago, it rapidly came into its own. A gang plow of four discs, drawn by eight to ten animals, probably shows the use of animal power before the plow at its highest point.

The prairie farmer, pressed for labor and handicapped by the growing cost of keeping horses, eagerly welcomed the first crude embodiment of mechanical power. Behind the light steam threshing engine, which was a revival of the ancient road locomotive, he hitched his own and his neighbors' walking plows. Weak, awkwardly coupled, and saving no labor, such ventures were doomed to failure. Even the gang plows which served so well with animals were unwieldy and entirely too frail when used behind engines; for engines have no instinct to warn them to halt for stumps and stones.

Low-down orchard tractor cultivating with a disc harrow

Automatic hay baler driver by an oil tractor

A 30-h.p. tractor and combined harvester cutting, threshing and sacking 100 acres per day

A 30-h.p. oil tractor hauling $22\frac{1}{2}$ yards of crushed rock

The disc plow maker was probably the first to seize his opportunity and build an engine gang plow adapted for both heavy work and easy manipulation. Gangs of from five to seven discs on a necessarily rigid frame, held in alignment by either three or four land wheels, provided with convenient means of coupling, and having handy levers, seat, and running-board, have proved the most effective in meeting the conflicting problems which arise in disc plow construction.

The moldboard gang for use with tractors first became a rigid frame carrying three to six bottoms, all lowered or raised at once. These in small sections strung out too far behind the engine, which had become much heavier and stronger. In large sections they did not adapt themselves to uneven ground. In either case an accident to one plow put the whole set out of commission. This has been overcome in later types of solid gang by using a spring trip which allows any bottom to be thrown up out of danger by the obstruction itself.

The larger the steam-engine for plowing, the more economical it is of labor and fuel in relation to output. The larger the engine, however, the wider the plow, and the greater the necessity for adapting it to uneven surfaces. The steam-lift plow, controlling its gangs by means of cylinders taking steam from the engine, taught hand-lift plow makers the importance of flexibility.

Finally we came to the highest achievement of the plowbuilder — the modern engine gang. Strong, compact, simple, flexible, with provision against serious accident, with provision for quick repair — a dozen makes divide a large share of credit for the commercial success of the farm tractor. The type with a lever to each plow is the most flexible. The type with two bottoms to each lever is in some respects easiest on the plowman. The type with two bottoms independently acting but lifting two at a time is a more complicated compromise.

The weight of a plow frame supported by the drawbar of the engine is designed to give the traction wheels a better grip. One plow is made in sections of four, five, and six bottoms, by the joining of which any size may be had with a flexible frame. By removing the landside entirely another designer reduces the draft far below the average. With all these plows extra shares and both stubble and breaker bottoms may be had. One or more plows are often detached in breaking sod, a heavy crusher attached to the frame taking their place.

Plowing, of course, is the tractor's first duty, but at the same time it may disc the ground. It may spend its power in deep plowing by day with either big discs or steep stubble moldboards. Three-sixteenths of an acre per hour for each disc or one-fourth acre for each fourteen-inch moldboard is fair capacity. Again the

tractor may be equipped with a headlight for working at night. The automobile is frequently the errand boy for a tractor outfit that never stops.

The ability of the tractor to combine operations appeals particularly to the farmer who wishes to hurry, to save repeated trips over the soil he has worked hard to pulverize, and to avoid loss of power in loose footing. The plow, the packer and the disc working together behind a tractor, will in a twinkling make a seed-bed out of a raw prairie.

With horses each implement must wait on the other, while the sun draws moisture from the unprotected soil in the meantime. With the tractor the drill, the disc, the packer, and harrow may work as one to give the seed every opportunity for growth.

The unfavorable results of many a poorly adapted outfit are held up as an object-lesson in traction farming. Horse plows, drills, and discs in a motley jumble and manned by a larger crew than necessary are still to be seen. Old-style engine gang plows, stubble bottoms working in virgin sod, and a very poor hitch are a combination scarcely to be dreamed of, but still found.

A farm-power magazine up in Canada has served its country well by collecting from various tractioneers detailed reports on the best hitches they have devised, and then publishing these at a nominal cost. Nothing done recently is of more practical benefit to power

farmers. The essentials of each hitch are strength, good alignment under all conditions, and convenience in hitching, turning and manipulating the implements attached. A good hitch hastens work, cuts cost, and by making more work for the engine, reduces the overhead charges on each acre.

Cradle and scythe have given way to the binder and header which appear in long lines in our great West. Now the sweltering horses are giving way to the small engine with two or three binders, or two larger ones with from four to seven machines attached to each other by means of patent offset tongues.

Treading out the corn by the unmuzzled ox gave way to the cleaner flail. The thresher with its ox or horse power emancipated the weary back. In modern days the tractor has long held sway over the bulk of the threshing business. Only the mammoth "combine" which cuts, threshes, and sacks all at once, seriously disputes this field with the stationary separator, and even this monster is drawn by the tractor.

The tractor, fitted with extension rims, conquers swamps where horses dare not tread. It crosses rough places in seeking its work. It fords streams where the country is new, or where enlightened laws have not come to compel safe bridges. Climbing mountains and freighting ore may be one part of its daily duties. Perhaps the house or the granary needs moving, or

perhaps it is a load of grain for the railway. Possibly the road must be built first, perhaps even the railway; and after sawing timber for bridges and ties the tractor must grade the embankment all the way from the farm to the flour-mill.

The tractor must at times haul its entire camp — separator, plows, tools, mounted fuel tank, and the cars for eating and sleeping. Its work often begins in the snow of Spring. It sometimes ends in the snow of Winter. No longer, as in the simple threshing days, does its work cease a short month after the click of the harvester stops. No longer does the wasteful glory of blazing strawstacks celebrate the beginning of its long vacation. The tractioneer is busy the whole year through.

Weary animals still plod back and forth through the long days of the fallow season. Droves of straining beasts still toil in the sun to glean the precious yield in the fat years when moisture has been saved. Some day, perhaps, a universal, motor-driven machine will supersede the plow and do all the dry-farmer's tasks for him. It is, however, doubtful. For the present, then, like the tired horses one occasionally sees leaning over the fence of the pasture, humanity is becoming more willing to let the tractor do the work.

CHAPTER X

WHAT SIZE OF TRACTOR?

FARMERS are calling for a small tractor, by which they mean one capable of doing economically the work of as few as four horses. At the present stage of the industry, a successful motor of that size cannot be put on the market, in competition with the cost of horses of equal power.

A horse at work usually develops less than a mechanical horse power. A four "horse" tractor, developing less than 4 horse power at the drawbar, would cost out of all proportion to its capacity. The biggest machines cost less, according to capacity, than the medium-sized ones, but only the occasional man has enough work to keep one busy.

The 35 or 40 horse power steam-engine sells for about $75 per nominal horse power. A 30 horse power gas tractor sells for about $85 actual drawbar horse power. A gas tractor of 15 to 20 horse power sells for about $100 per actual drawbar horse power.

If a man has plenty of work, he wants a big engine. If he has only a little work, he had better use horses.

If he wants to plow economically, run a fair-sized separator or huller, shred or shell corn and haul a handy load to market, the medium-sized gas tractor presents a combination of handiness and economy not to be found in either the largest or smallest engines, now successfully on the market.

The following is a comparison of medium and small machines, in actual tests. The medium-sized outfit pulled eight 14-inch bottoms continuously through sod and the small one handled four 14-inch bottoms, both plowing four inches deep:

	Medium	Small
Weight per actual brake horse power	420	543
" " " drawbar " "	700	827
Price per actual " " "	$83.50	$103.00
" " " brake " "	50.00	67.50
Labor, cost per hour, cents	.50	.50
Acres, per hour	2.25	1.14
Labor, cost per acre, cents	.22	.44

Even the smallest practicable tractors of today, which are much larger than the farmer's ideal of a 4-horse rig, are not so economical as the medium-sized rig for heavy work, and still are not adapted to take the place of horses to much greater extent than the latter.

A consideration of the biggest work of the tractor — plowing — will help us to judge, in a practical way, the best size for a given farm. No engine will pull the same number of plows under all conditions, owing to grades and differences in soil.

Say a medium-sized rig weighs 21,000 pounds, or 10.5 tons. On a good level dirt road it takes a draft of about 140 pounds to move a ton of load, including the weight of the wagon. To move merely the weight of the engine, over the same road, if the friction of wheels, etc., were no greater than with the wagon load, would take practically 10 horse power at 2.5 miles per hour.

For every per cent increase in grade, i.e., every foot rise in 100 feet, it would take an additional horse power at the same speed of drive-wheels. The forward speed would probably be less because of slippage. The friction of engine gearing is, of course, greater than that of a wagon wheel and axle, so from 20 to 25 horse power out of 50 horse power developed at the crankshaft should be reserved for moving the engine, for climbing grades, and for overcoming sudden obstacles requiring extra power.

A 14-inch bottom, plowing five inches deep, will usually have a draft of 350 to 400 pounds in stubble, and at $2\frac{1}{3}$ miles per hour will take from 2.2 to 2.5 actual drawbar horse power to pull it, according to the formula:

$$\frac{\text{Draft (350)} \times \text{speed (2.33)}}{375} = \text{horse power.}$$

The draft of the plow is only slightly heavier on a grade, but if it takes from 1 to $1\frac{1}{2}$ extra horse power to

move the engine, for each rise of 1 foot in 100 feet, it can be seen that an engine pulling a full load on the level must develop more power or pull less load on a grade.

A horse walking up a 10 per cent grade at 2.5 miles per hour uses as much power to move himself as he can ordinarily and continuously exert on the level. He can usually exert a pull of one-tenth his weight on the level at that speed, and on a 10 per cent grade this power is all consumed in moving himself. He can, however, for a short time, double his usual working power without injury and thus get up the grade with the ordinary load. By stopping and resting, by taking very short spurts, he can still pull his load on a grade as high as 35 to 40 per cent.

No engine is capable of running economically on the level and exerting any such overload on the hills; but by stopping, getting up speed and letting the momentum carry the engine and load forward, a good operator can get much more than the ordinary overload capacity out of an engine.

Supposing the drawbar pull of the engine to be constant, the number of plows that can be pulled on the level varies with the kind of soil, the size of the furrow, and the make, adjustment, and condition of plows. The best way to compare draft is by comparing the draft per square inch of cross-section of furrows.

A furrow 6 inches deep and 14 inches wide has a cross-

section of 84 square inches. The draft per square inch runs as low as 3 pounds in light sandy soil, and probably up to eight or ten times as much in baked clay soil. Fifty-seven tests in old ground, both sod and stubble, at the Missouri Experiment Station, averaged 5.98 pounds per square inch. In virgin gumbo sod, at Winnipeg, the draft averaged 13.7 pounds per inch for 7 outfits, and in part sod and part old ground 11.5 pounds for 8 outfits. One make of plow averaged about 1.5 pounds per square inch less than another. But one plow of the first make, which had been used for some time in stony ground, showed a draft of 15.6 pounds per inch. A dull plow, or one out of line in any way, takes extra power.

The size of the furrow makes a difference in the draft per plow, aside from the amount of soil turned. About 55 per cent. of the draft of a plow in good condition is used by the shin and share in cutting the furrow, 35 per cent. is caused by the friction of the sole and landside and 10 per cent. by the work of turning the furrow by the moldboard. A dull plow will greatly increase the work of cutting. A small furrow will present a longer cutting line in proportion to area than a large furrow.

One plow company states that the usual draft of a plow cutting a furrow 6 × 14 inches is from 300 to 400 pounds, or from 3.6 to 4.7 pounds per inch. Another gives results of tests, showing an average draft of 4.3

pounds per inch, and still another gives tests ranging from 3.5 to 8 pounds in various soil conditions in Illinois, Wisconsin, and Missouri. To guarantee the number of plows that can be pulled, therefore, is impossible. The usual working draft of a good horse is about 150 pounds. By taking the average furrow plowed by horses, some idea of the draft per inch can be ascertained and this can be applied to any case in question.

Speed has practically no effect on the draft per plow, but has on the power required to pull it. A plow of 400 pounds draft at two miles per hour will have only a trifle more draft at three miles per hour, but a half more horse power will be required to exert the same pull at the higher speed. More plows can be pulled with the same power at the lower speed.

A tractor with a forward speed of 1.75 or two miles can pull more plows in proportion to actual horse power than another at 2½ miles, but, of course, the distance traveled per day is less and this balances the extra width of cut. Given the same draft of plow, the work done in plowing an acre will be practically the same, regardless of speed. The only difference would be in the power required to do the work in different lengths of time.

A 14-inch plow, in turning an acre, must be drawn 37,337 feet, or 7.07 miles. If a plow goes 7.143 inches

deep, it cuts a cross-section of 100 inches. If the draft is 3.5 pounds per inch, then the draft of the plow is 350 pounds. The work done in plowing an acre is equal to 37,337 × 350, which is 13,067,950 foot pounds. (A foot pound is the measure of work done in lifting one pound one foot in a vertical direction, regardless of time, and is used in measuring draft, the resistance of a plow to a spring being measured on a scale in the same way that a suspended weight is registered on the scale of a spring balance.)

A horse power, which introduces the element of time, is the measure of force equivalent to lifting 550 pounds one foot in one second, or 550 foot pounds per second, 33,000 per minute, and 1,980,000 per hour. In plowing an acre under the above conditions, the horse power hours required would be 13,067,950 divided by 1,980,000 or 6.6. This might be done by two horses at the rate of four or five hours per acre; or it might be done by an engine at the rate of a few minutes. One steam-engine plowed at the rate of an acre in 7.58 minutes at the Brandon (Man.) Motor Contest in 1909. But the horse power hours and the amount of work per acre would be about the same in either case. If the draft per inch had been 14 pounds, which is not too high to expect in prairie sod, the horse power hours required would have been four times as great, or 26.4 per acre. At Winnipeg in 1909 one gang plow required 11.8 horse

power hours to plow an acre, another make 12.9, and a dull one of the first make 16.4. All were in raw sod breaking, and supposed to be at the same depth, about four inches.

From this it can be seen that it takes power to plow and plow deep. Deeper plowing is what agricultural experts are recommending with one voice. If the four-horse team is already plowing as deep as it can profitably go, why replace it with a more expensive machine, capable of doing only the same amount of work? The larger the machine, the less it costs per horse power to buy and operate. Why not have plenty of power, since all sizes of tractors cost the same for maintenance during idleness — that is, nothing?

CHAPTER XI

THE PROBLEM OF THE SMALL TRACTOR

PERHAPS the livest question in the minds of farmers, agricultural engineers, and manufacturers at the present time is that of the small tractor. Factories on all sides are springing into existence to build this ideal of the 160-acre farmer. Farmers and college professors everywhere are clamoring for it, and the general opinion is that a successful small tractor will be the solution of the labor and power problems that are so keen with the average farmer at the present time.

The most pressing need of the small power-farmer (considering 160 acres as a small farm) is a light, durable tractor, lower in first cost, maintenance, and cost of operation than the animals it will replace; with a wide range of flexibility, and capable of utilizing whatever fuel may be most abundant and most easily secured.

It must do economically all that a big tractor will do; for example, — drive all sorts of stationary machines, to plow, pulverize the soil, seed, harvest, grade roads, and haul the crop to market. It may even properly be

expected to cultivate corn and do many other tasks that are now done exclusively by horses. The man who brings forth a tractor which will do all of these things has a clear road to fortune, for no one as yet has even approached this ideal.

The small tractor must be more than a miniature copy of the big one. Its success will depend on the doing of many jobs that require only one or two horses, and the doing of them cheaply. It must really replace the horse. The popular tractors of the present do not — entirely. The small farmer cannot keep several of his present work animals and still buy a machine without increasing his investment.

The farmer with twelve or more horses can sell two out of three, or even three out of four. He can buy a 15-horse power tractor with the price received for that many good animals, and store and operate it afterward at a much lower cost than that of the horses displaced.

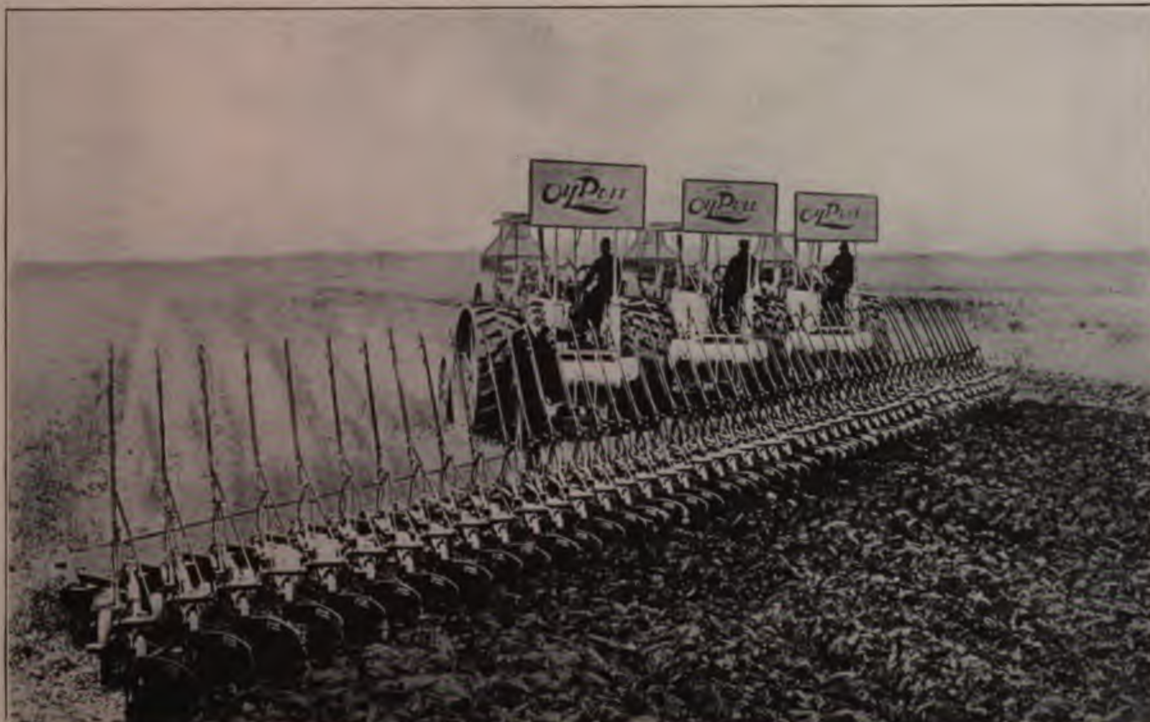
The small tractor must do such widely separated tasks as cultivating and plowing, sawing stove-wood and filling the silo, and do all cheaply. It must stand still and pump water or grind feed without overheating, yet be light enough to take the place of one or two horses in carrying a light load rapidly to town and back. It must do and be things that have never been expected of a big tractor. It must be part horse, part automo-

bile, part tractor, part wagon, and almost human, if it fulfils the requirements.

The mechanical difficulties are tremendous, and up to the present time, even in Europe where the small farmer's problem has been uppermost from the beginning, the successful small tractor has not yet arrived. In every agricultural motor contest held abroad during the last two or three years an American tractor of nearly twice the size demanded by the "small farmer" has carried off the honors. Abroad, as at home, the effort to meet all the requirements outlined has resulted in many freaks and few "bull's-eyes."

The small tractor, as at present built, requires two men, the same as the large one, or else wastes the operator's time as he steps from the engine to the drawn or driven machine and back again. To overcome this difficulty by building a combined machine solves the problem for one operation and complicates it for every other. For example, the distribution of weight and material necessary to make a successful self-contained plowing outfit may reduce the effectiveness of the machine for pulling a load strung out behind like binders.

Plowing is of course our greatest farm power problem. Practically every tractor is designed so that both drive wheels must run on the unplowed ground, hence the plow must be in line with the right side of the machine.



The World's Plowing Record — an acre in four minutes and fifteen seconds

Gas tractor plowing, seeding and harrowing all at once in stubble ground

Small gasoline tractor breaking virgin sod and packing it

The width of the tractor cannot be decreased in proportion to its power. The larger tractor plows out its own width, but the smaller one cannot. Deeper plowing is consistently urged by our leading agriculturists. The deeper we go the fewer plows we pull, the greater the side draft and the more unequal the strain on the tractor. It is a real mechanical difficulty which is not met with in the tractor powerful enough to plow out its own width.

On striking an obstacle the big outfit can calmly break off a plow and leave it hanging on the rock or stump without affecting the massive frame or gearing. Not so with the small machine which pulls but two or three plows. A stump presents a resistance sufficient to stop it. Something must give. Either the plows must be made so much lighter as to endanger their usefulness, or greater flexibility must be provided for the tractor's transmission. This at once suggests the friction drive, with all its accompanying troubles, and is another problem for the designer.

With all these difficulties, however, the number of engineers working on the small tractor problem is so large that we can look for a solution in the near future. The unavoidable disadvantages must be accepted, just as they are with every other type of machine and every other form of power; but the small tractor will have its place and reach a tremendous sale.

However, the economic difficulties referred to elsewhere must be considered quite as fully as the ones which confront the designer. Nevertheless, the question always arises as to what its ultimate outcome will be, and here is where the one who raises the question must disclaim all responsibility for the soundness of his argument.

Having done this, let us see what the causes are that may lead to the disappearance of the small tractor and the small farm together, speaking, of course, of the type of farming adapted to machine methods. The subject is too grave to be treated lightly. If suggestions are made that cannot be generally entertained, it is with the idea of stimulating thought as to the farm tractor's influence upon the future of our agricultural class.

Farm machinery was wonderfully developed in the last three decades of the nineteenth century, thus elevating the farm laborer from a mere drudge to a skilled operator of mechanical devices. The machine cheapened the cost of production and bettered both yield and quality of crop. It enabled a lower percentage of the total population to produce the food required to supply the nation's needs and build up an enormous balance of trade with foreign countries.

The laborers who were drawn to the cities by the growth of manufacturing and transportation in the latter half of the century, were replaced on the farm

by four times the previous number of horses, with each animal averaging twenty-five per cent. higher in efficiency. Significantly enough, the productiveness of each farm laborer increased practically five times in the same period, indicating a close relationship between the amount at a man's disposal and the amount that he can produce.

All of these improvements in machinery substituted interest on investment for wages paid to labor. The farmer became unable to buy sufficient labor and pay for it piecemeal. He found it necessary to buy, in its stead, machines which would take the place of laborers for a period of eight or ten years, but only a year or two were allowed at most for payment. Thus the investment in farming became much greater. The rise in the price of land further tended to decrease the number of producers who were also owners, and to increase the number of non-resident owners who could balance their capital against some other man's labor.

These things had taken place before mechanical power seriously began to invade the farm. Steam made possible the development of industries which are best carried on in centralized plants. Mechanical power created the cities and now the factory is sending other mechanical devices back to the farm to take the place of the laborers who are being lured away from its isolation. It seems foolish to maintain that the same

reorganization which has taken place in the factory and on the railway will not tend to reappear on the farm when mechanical power exerts its full influence.

Mechanical power cannot be applied as easily to the farm as to these other industries. Work can be brought to the factory and the engine remain stationary, but on the farm the power plant must go to its work. The limitations of soil, topography, etc., impose difficulties not met by any stationary engine designer. Nevertheless, the tractor has come to stay on our farms, and recent demonstrations of multiple-engine outfits drawing gangs of fifty or more plows suggest that if it becomes necessary, power can be applied to agriculture on a scale heretofore undreamed of.

The tractor is cutting costs and placing the farmer in a more independent position with regard to climate and other conditions. Mechanical power is enabling larger areas to be cultivated with the same care as before and smaller ones to be cultivated more intensively. Either way, the machine increases the effectiveness and the profits of the farm workman. The larger the machine, the more economical, and the larger the farm, the greater the possible profits and the finer the opportunity for the well-trained business man to exercise his managerial ability. The farm does not now require brute force and physical endurance so much as careful management.

The city business man, who had neither the taste nor the physique for farming in the last generation, is now being attracted to it as an active occupation. Other business and professional men with idle capital are finding that the farm offers a safe and paying investment. The capital required for proper organization is increased, and the city, which has so long drawn capital from the country and made it pay a profit, is now sending money back to increase further the profits from the original source.

The man with only his labor to sell, and the man with his labor and only a small capital, are beginning to feel the competition of farms operated on a larger scale, with better trained men, better machinery, and more economical power. They are feeling his competition just as the wheat-growing farmer in New England, with no far-seeing adviser, often abandoned his farm before the advance of the gang plow and the binder on the Western prairie. It seems inevitable that the large farm and the large tractor should come into wider instead of narrower currency. The ideal of the "little farm well tilled" is being superseded by that of the big farm better tilled and better managed.

Fortunately, co-operation among farmers is a thing which has been proved practicable in hundreds of instances and is a movement which seems to be spreading. Unfortunately, the movement at present seems

to be confined more to those types of farming that involve the producing of fruits and vegetables and their marketing at a considerable distance, than to grain raising and general farming. Owners of farms adapted to the use of large implements and power machines have been slow to act.

This is undoubtedly due in most part to the fact that they have never felt the pinch of necessity; but there are other limitations. It may be necessary to do some real engineering work in fitting the smaller farms for the use of the large machinery. The 50-plow outfit cannot be used in a strawberry patch. Neither can it be used on a ten-acre hillside farm. Many unavoidable factors will limit the size of the equipment, but removable causes, such as the present location of fences, roads, and buildings may interfere with the operation of the neighborhood tractor. The co-operatively supported agricultural engineer will undoubtedly be called in consultation before the final solution is reached.

Even after the reconstructive work has been accomplished, a community ill-advised from the business standpoint, may find itself unable to compete in a certain type of farming with more favored sections. It will take brains as well as power to farm profitably in the future. The average man is not a leader, else he would not be an average man; but if he works in harmony with his neighbor he can secure the services

of leaders and equipment that will enable him to maintain his home- and property-independence and still reap a profit.

The small tractor is coming immediately. The large tractor, which is the four-horse team among farm machines, looms up, threatening to displace the small farmer's power. With the large tractor making for greater profit in large-scale production, there comes the question of larger farms, more capital and possibly capitalized ownership. Effective co-operation is the only alternative. It is up to the man on the farm. What is he going to do about it?

CHAPTER XII

POWER-PLOWING IN SMALL FIELDS

MANY progressive farmers have no really clear idea as to the advantages and disadvantages of power-farming. Nor can we blame them, for power-farming is revolutionary — it can't be grasped all at once.

The first thought always seems to be — not whether the outfit will pay, but — a question as to how anything so big and awkward and ungainly as a traction engine and plows can turn around on an ordinary field. All of which, analyzed, usually shows that the questioner has in mind a big steam threshing outfit, and associates the bulky separator with the engine. Or that he has in mind a string of ordinary gang plows, rather than a compact, modern engine gang. Or that he has never seen an up-to-date gas tractor and an engine gang at work.

Now traction plowing is practicable in fields as small as ten or twelve acres; and by that we mean that good time can be made. "Now," says some one, "that's all right for big fields where they can drive out on the

road to turn around, but not for fenced fields." That is a common verdict, but just wait a bit. Did you ever hear that modern proverb about things moving so fast nowadays that the fellow who says a thing can't be done is often interrupted by the noise some other fellow makes doing it?

Out in Iowa last spring one traction-farmer started off his season's work by plowing a three-acre garden patch with his tractor.

A Georgia power-farmer plowed a 2½-acre field in two hours with a 15-horse power tractor.

Down at Purdue University, Prof. W. M. Nye stood a while watching the maneuvers of a 3-tractor 50-plow outfit in a 20-acre field, and then exclaimed, "If that big outfit can work in here, that little one over yonder (a 15-horse power kerosene tractor and six plows) is certainly practical in the fields we have in Indiana."

The writer saw last season the start and finish of a 15-acre fenced field which was plowed out in a trifle less than 13 hours' time with just such a 15-horse power tractor and plows.

The field was 40 rods wide and 60 rods long, or 660 feet by 990 feet. The plowman had a calculating head on him, and he figured a little bit on just how to lay out the field so when he got done he would be all done and come out at the corner gate without running over any plowed ground.

Naturally he needed some room to turn on at the ends, so he first measured off the width of 9 rounds (63 feet) from the fence at either end of the field. This of course decided the distance to be left at the side also, so a stake was set at each corner 63 feet each way from the fences. That left a width of 534 feet to be plowed in "lands," and this equaled almost exactly 458 furrows.

Now in laying out the lands it isn't always possible to come out just even. Sometimes, in a tough spot, one plow may have to be lifted for awhile. Another time, perhaps, the tractioneer gets the front furrow a little wide on one side and a little narrow on the other. However, the plan must be good or the result can never be, so this plowman did the best he could.

He had three problems: First, he wanted to back-furrow and finish each land at the starting end of the field. Second, he wanted to be sure of plowing out the remainder of his land at the finishing trip, so as to leave a smooth dead furrow. And, third, he did not want several plows to hang over on the other land on the last time through, and drag their points in the loose dirt. Added to that he made a practise of pulling one less plow than usual when striking out a new land. In order to get in all these points, he decided on odd widths for his lands, namely, 140, 152, and 166 furrows, corresponding, respectively, to about 163, 177, and 194 feet.

By planning on but five plows for the finishing trip for either of the two outside lands, he had one to drop in occasionally where the ground had been skimped on former rounds. But if his driver had not been very careful all along this one plow would hardly have been enough in places. With a little practise the dead furrows will be left cleanly marked, and even an amateur's work can compare favorably with his first attempt with a walking plow.

The plows were lifted at either headland, the outfit turning on unplowed ground. This brought the last trip back toward the corner nearest the gate. When the outfit all but reached the headland, the plowman began at the rear end of this string of levers, and the lifting of the plows in this order left the furrow ends on a diagonal instead of square across like all the others. The tractioneer now swung around a circle to the left and came in at right angles to the furrows. This time the plowman followed the usual order but dropped his plows more slowly, hence there was another diagonal. This process was repeated twice at each of the four corners, and on the third trip the plows were not lifted at all, except the right-hand one at the sharpest turns.

In swinging around the curves this way it was inevitable that a triangle in each of the four corners should be left unplowed. Yet, like the few kernels of wheat that seem like a hail-storm when blown through a wind

stacker, these triangles seem bigger then they are. The one in the starting corner is all but wiped out the last time when the outfit comes down the fence and cuts out a full strip to the very corner. Even disregarding this, and measuring every foot of ground left after a very easy curve has been made, the total in each corner amounts to a trifle under 3,300 square feet, or less than .08 acre. Four corners mean less than one-third of an acre either wasted or plowed out by other means. Two horses and a man are supposed to plow two acres a day with a walking plow, and could surely do the four corners in three hours.

Against this matter of the corners, let us figure on the time of plowing the whole. It would take the two horses and a man seven and a half days, or three horses and a man five to five and a half days, at a cost of 8 cents per hour for each horse and 15 cents per hour for the man — $1.43 to $1.55 per acre besides a plow cost of about 8 cents per acre.

The tractor will net, at the lowest estimate, 1.8 miles an hour of travel after deducting slippage, and if we assume an average of only 5½ plows to allow for other delays than turning, the outfit would still plow 1.4 acres per hour. The whole would take 10.7 hours at that rate, but we must also add time for turns — about 45 to 60 seconds each where plows are lifted. Eighty-six turns would add nearly an hour and a half and by in-

cluding the time required to stake off the field properly we can account for about thirteen hours of time, or less than one and one-third days.

A very liberal estimate of the cost with the tractor will then be about as follows:

Cost of tractor work

Interest, repairs, and depreciation on engine ($\frac{1}{8}$ first cost each year — one hundred days' use), one and one-third days @ $2.83	$3.78
Interest, repairs, and depreciation on plows ($\frac{1}{10}$ first cost each year — fifty days' use), one and one-third days @ $0.84	1.12
40 gallons kerosene @ $0.06	2.40
Lubricants	.80
Board and wages, two men @ $5 per day	6.67
Use of men and horses, hauling oil (one day in two weeks), one and one-third days @ $0.26	.35
Use of men and team, plowing corners, three hours @ $0.31	.93
Total	$16.05

In the foregoing costs, everything, overhead charges and all, that can reasonably be figured, is included, and at much more liberal figures than results usually show; yet the entire cost is only $1.05 as against $1.63 with horses. If these figures can be regarded as average ones, then on larger fields than fifteen acres the tractor is both practicable and economical, while the size of field could run down to eight or ten acres and the cost still meet present costs with animals.

Below eight or ten acres the practicability of a 15-horse-power tractor will depend more and more on individual circumstances — the skill and management

of the operator and the premium that can be earned by getting the work out on time. Going back to the beginning, however, we can answer the usual question by saying that plowing with a tractor is profitable on average 160-acre farms. It will be more so when rotations and fields are planned to allow large machinery to be worked with fewer turns and with longer runs between headlands.

CHAPTER XIII

THE TRACTOR IN THE CORN BELT

THE farm tractor is all right for the big farms in Dakota and Montana — nobody doubts that. People are more apt to disagree when we say the farm tractor is all right for the 160-acre farmer.

Let us figure what the farmer has to do: Suppose he has 40 acres of corn, 40 acres of hay, and 40 acres of small grain, and plows 80 acres a year. Just for argument we will suppose that he does merely his own work. That will make it a little harder for him to make good, but the tractor will cost more than almost any two or three other machines; and if he wants to get the most out of it he will have to equip himself with machinery that he can run with it. At the present time, of course, the owner of a small tractor can figure on plenty of outside work, and the cash thus earned is a big help in paying for the engine.

Starting with the corn crop, he can disc the ground before he plows it. He can wait until the ground gets dry and warm on top before he starts. Then, when it is disced up and plowed under, it will be many degrees

warmer down where the seed goes. The loose soil and chopped trash will mold nicely in with the subsurface soil, much better than if the crust and coarse trash were dumped down on top of the hard layer under the ploughshare. He can wait to begin operations until his ground is in fit shape to plow, because he has the power at his command to catch up with his neighbors who had to start early for lack of horse-flesh.

He will want a two-speed tractor that will develop the power of twelve to fifteen horses on the drawbar, day in and day out. That will cost him about $1,600 to $1,800. A smaller one might do, but the smaller they are the more they cost in proportion to horse-power, and he will find that the ability to rush work when he wants to rush it will pay in the end.

That size will handle five or six 14-inch stubble or general purpose plows at a depth of seven or eight inches and practically plow out its own width. It will net him about $1\frac{3}{4}$ miles of plowing an hour after counting out turns and stops, and if he puts in ten hours a day in the field on the days he can work, his corn ground will be plowed in a week.

The previous discing will be a matter of two days, and the first discing after plowing can be done with a disc hitched to the rear of his plows. Another two days with disc and harrows will leave him an ideal seed-bed and save a lot of cultivation afterward.

Gas tractor with 50 feet of grain drills

A steam tractor thresbing in Minnesota, burning straw for fuel

This man, two boys, two horses and a tractor handle 240 acres of Minnesota land

The tractor will haul his corn binder — two if he is able to borrow an extra one; run his ensilage cutter, shredder, sheller, or grinder; and haul the surplus corn to town at a lively gait. The saving in horse feed will give him a larger surplus to market for cash and still leave him the usual amount to turn into beef and manure. When you figure that for every able-bodied work horse you feed the crops from about four acres to him and the breeding horse stock, the tractor's possibilities in the way of increasing the cattle, hogs, and soil fertility begin to warrant a little figuring.

Next the hay crop. With the new hitches that are on the market, the tractor can pull two mowers as easily as one, and there is nothing but the lack of a little ingenuity to hinder the use of the engine ahead of a big hayrack and loader. It has actually and profitably been done. The horses that are kept for the easy jobs of planting and cultivating the corn can do the raking and tedding, and leave the heavy work for the machine that doesn't get tired. The baling press run by the tractor will either cut down the space needed to store the hay crop, and reduce the cost of marketing, or it will add to the sale value of the crop — probably all three — and the tractor will take a lot of hay on one trip to town.

The plowing for the small grain crops can be done whenever the time is ripe, and done quickly. Every

job connected with the crop can be done with the tractor — plowing, discing, packing, drilling, harvesting, threshing, hauling, and grinding — at a saving which amounts to an enormous added percentage of profit on the cost of production.

Another valuable use of the tractor is in modern harvesting.

The man with the sickle had a back-breaking job and made slow time in gathering the harvest. A six-foot binder with three or four horses takes the place of forty men with sickles, and one man drives the outfit. The invention of the reaper made it possible for America to be settled within the swift space of fifty years.

Even the modern binder, however, is handicapped because it can be used only in the hottest part of the summer and must be used every possible moment then in order to gather the crop when the weather is fair and when the quality of the grain is at the highest point. This requires power. But with all his excellent qualities, the horse is unable to endure the work of harvest for more than six to eight hours a day, so the farmer fails in getting the most out of the binder. Without several shifts of teams the speed is apt to lag toward the end of the day and the binder will do a poorer quality of work.

Plowing with traction engines, especially in the wheat-raising districts of the Northwest, is so common

as to excite very little attention from the passer-by. Power harvesting, however, is rather a new departure, even there, and it is only just beginning to get under way in the corn belt.

Our illustration shows a man with a small kerosene tractor operating two binders, his two small sons enjoying a comfortable ride and operating the levers. The man and the two boys, making $2\frac{3}{4}$ miles per hour on high gear, and keeping in motion ten hours out of the twelve that are spent in the field — more hours if necessary — are able to cut forty acres in the average day, and the tractor is no more tired at night than in the morning. The tractor and the two binders cost about 39 cents an acre to operate, including the twine, fuel, labor, interest, repairs and depreciation. Seventy-five cents is the usual figure with horses.

After the crops are disposed of the farmer still has uses for his engine. It will probably be too big for profitable use in pumping water from a well, but it will saw the winter's wood supply in a hurry. It will tickle the road supervisor when hitched ahead of a road grader. It will haul the heavy supplies to the farm. It will do any of the big jobs that are constantly being left undone for lack of power.

True it will balk sometimes, and sometimes a trifling part will break at the wrong time. But where is the farmer who has not had a sick horse, or even a dead one,

on his hands when he needed power the most? Twenty thousand plague-stricken horses died in six weeks in Kansas and adjoining States during the harvest of 1912; and each year thousands die from the heat in the harvest field.

All this recital of what the tractor will do sounds a little too good to be true. We have never found a farmer who was doing *all* these things, but they are all being done by farmers somewhere, and more too.

It will probably be a surprise to learn that one large tractor manufacturer reports about ten per cent. of his sales in Indiana, Illinois, Iowa, Missouri, the eastern half of Nebraska, and Kansas. The writer is in correspondence with a good many farmers and in one day in 1911 received eight letters regarding tractors used that season in Iowa. He cannot guarantee the absolute accuracy of every statement but passes a few of them on for what they are worth.

A Webster County man used a 15-horse-power traction engine for shelling, threshing, grading roads, and plowing. He says his road boss congratulated him on doing more work than he used to do with a steam-engine rated at higher power. This was simply because the work could go on all the time, without stops for water and coal.

In threshing he found the engine always ready to start, as he made it a practise to fill up with kerosene

the evening before. With his old steam-engine it was almost impossible for the engineer to get steam up before the crowd of hustling farmers got on the scene ready for work. He used a 32-inch separator with feeder and wind stacker and pulled four 16-inch plows in stubble.

Out in Pocahontas County, Iowa, a man with a smaller engine used it to haul tile to his farm, taking six wagon loads at once. He also threshed with his engine and claims that he could make five miles in an hour and a quarter on the road. He also plowed nearly three hundred acres, using four 14-inch plows on the high speed or at the rate of about two and three-quarter miles per hour. His fuel cost $1.70 per day as an average for all kinds of work. He ran the engine alone and made more money than a much larger steam outfit in the same neighborhood because he could afford to take smaller jobs.

In Buena Vista County a man with the same type of 15-horse-power engine took $300 worth of work away from a steam outfit in addition to what he had previously booked. Water was scarce in the fall and many farmers transferred their jobs rather than have their wells robbed. Several switched because in such a dry season there was much less danger to their buildings with an oil engine than with steam. He reports from $1.30 to $1.80 per day for fuel which a tank wagon

delivered to him on the job at six cents a gallon. Another man in Emmet County ran his eight-roll husker and shredder with an engine of the same power.

These smaller outfits are much the more popular and numerous in Iowa and the surrounding States, but there are many big jobs and many men who buy large gas tractors to replace steam. A Hancock County man with a 30-horse-power tractor put in several hundred acres of plowing with ten 14-inch plows and wound up the season with thirty days of road grading, without ever exceeding $3.25 per day for fuel and lubricating oil. A neighbor of the first Pocahontas County man used a 30-horse-power tractor to drive a 36-inch separator and said that even with four pitchers there was plenty of power. He kept close track of his fuel costs and averaged $2\frac{3}{4}$ gallons of kerosene to the acre on 400 acres plowed. This fuel cost him six cents a gallon, delivered in the field.

Over in Fayette County a purchaser ran a ten-roll corn shredder all fall, handling twenty-five to thirty acres of heavy fodder per day. After the shredding season he put the engine to work in a large feed mill. The machinery which it ran there included a 52-inch stoneburr feed mill, a 32-inch stationary mill, a corn sheller, and a corn-cob crusher, with the necessary elevators. Its capacity with this machinery is thirty

to thirty-five sacks per hour and the owner says it has never been run anywhere near maximum.

The last man's experience was unusual. The only experience this customer had had with an engine was a 3-horse-power stationary motor, but when the tractor came he received it, settled for it, and took it home before notifying the company that it had arrived. He had no expert then nor later and has had no trouble, even with the thermometer at thirty degrees below zero.

There are many instances all over the corn belt of farmers who have had similar successes with their machines. Of course not all are so successful; but one day's correspondence from one of the typical corn belt states brought in these eight experiences. They certainly are strong proof that farmers are finding more and more use for tractors and that the day has gone by when an expert from the factory must stand in attendance on each machine.

One other man in the corn belt recently reported that he had been stretching hog wire, another moved a house, another dug a ditch, and another filled his ditch. Traction farming will never be a universal success until all men learn the possibilities in tractors, but they are learning fast, with satisfactory results.

It takes a little patience and study to rig up for all these jobs; but the point made is, that a man on a

quarter-section *could* do all of them if he set out to do so. Not only that, but he would constantly be finding new uses that would pay, and so reduce the size of farm that could afford to maintain a tractor.

The ordinary man, after getting used to two or three operations, leaves the rest and sets out to work for his neighbors. Until the number of tractors is much greater, he is justified in doing it. After allowing for his own labor, $4 a day for interest, wear and tear on his engine, and 30 to 35 gallons of kerosene at 5½ to 7 cents a gallon, he can still earn a good profit on his plowing, threshing, sowing, shredding, shelling, etc.; and it is an easier way to make the tractor pay than by doing his own work.

The time will come, though (first to the half-section farmer, then to the 200-acre man, and finally to the man with a modest quarter), when he will have his hands full at home. He will find that by applying more power to every acre of ground he will have more crops to handle. He will intensify his farming by baling his hay and straw, shelling and grinding his corn, cutting up his fodder, and carrying every crop along to as highly a manufactured state as can be done on the farm.

The great trouble with our farming at present, as well as with our manufacturing, is that we do not create enough value out of our raw materials. We use power

abundantly to dig a lot of wealth out of our soil and our mines, but we do not apply enough power in turning the raw material into highly finished products. The farm tractor affords the opportunity to do things better on the farm, and is practicable if the right man is at the steering wheel.

CHAPTER XIV

THE TRACTOR ON THE FRUIT FARM

FRUIT farming is highly intensive. The tractor, on the contrary, is popularly supposed to fit in only with extensive agriculture. A little consideration will show how mistaken this idea is. In the first place, fruit farming is done on land that is three times as valuable as the best of the ordinary farm land. It is far too valuable, therefore, to waste on pasture for work animals. Yet there are many seasons of the year when pasture space is absolutely necessary for the health of the horses, — seasons, too, when there is no work for them to do. The tractor is never tempted by a browsing-ground.

Let us grant, however, that the horse may safely be kept in the stable all his idle time. That means, as shown by Government statistics, nearly 170 hours of man labor per year in caring for *each horse*. It means, as found by the Ohio Experiment Station, 90 square feet of floor space and 750 cubic feet of barn room for the accommodation of each animal, besides at least 1,300 cubic feet of hay storage and 100 cubic feet of

grain storage to hold the 6,500 pounds of hay and 3,600 pounds of grain consumed by each animal during the year. Lumber is becoming increasingly scarce and costly. The problem of housing the farm motor and its food or fuel deserves serious consideration. The tractor greatly simplifies it.

Take, for instance, an ordinary type of farm tractor, of capacity equal to fifteen horses. It is about 16 feet over all in length by 7 feet 6 inches in width, or 120 square feet. It is, roughly speaking, 10 feet to the top of the removable canopy, hence the tractor itself could be placed in a box containing 1,200 cubic feet. Assuming it to be worked the same number of hours per year as the average farm horse (approximately 1,000) and even at *full load* all the time, it would consume only about 400 cubic feet of kerosene. Allowing for the necessary waste space and for passage room it is safe to assert that this tractor and a year's fuel could be housed in one-tenth the space required for horses of equal power and their annual food supply. Furthermore, there is no waste space in pasture, watering yards, etc.

"But," you say, "the barn doesn't have to be made large enough to hold feed for a year." No, but since crops are raised but once a year some one must store them or they spoil; and you may rest assured that Somebody, otherwise the consumer, pays that storage cost.

On the other hand, crude oil is pumped from the

same wells every week of the year, and its products, gasolene, kerosene, and other distillates, come to you from month to month with very little fluctuation in price and quality. You can buy fuel any time, but feed you must figure on a long time ahead.

Now, what will the ordinary tractor do? It will pull from four to six plows, according to kind of soil and depth of plowing. It will pull as many discs and harrows or cultivators as can be manipulated behind it. It goes in the middle between the rows, sparing the limbs of the trees, while on either side, right up to the trees, run the low-tillage tools.

It will pull a heavily loaded wagon out of the mellow orchard soil after gathering up the fruit. It will pull a heavy wagon train to the railway, a carload at a trip, saving many teams and men to drive them, at a time when every available hand should be busy stripping the orchard of its yield. It will bring its own and the farmer's supplies from town. Belted to stationary machines it will furnish power for tasks too numerous to contemplate.

The farmer with the ordinary farm tractor can use it in the orchard; but now we have tractors built low-down and narrower still, for orchard work. What orchardist is there who could not use a 4-ton tractor less than five feet high and six feet wide, which can turn short from one orchard row into the next, go under the

limbs, close to the trees, and by reason of its peculiar drive wheels shape, leave the ground loose and mellow on top?

Such tractors, already used by many California fruit growers, are bound soon to invade the East, and put orcharding on a more profitable basis. The tractor may be the one thing, beside co-operation, that will enable Eastern and Southern growers to compete with those in the wonderful West.

But, and let us emphasize it, the tractor will not be cart horse and automobile at the same time. If it is a cross between them it cannot be used satisfactorily for either. No farmer expects the same horse to be not only plow horse but a roadster to be proud of. The dual-purpose cow is only a poor average between two extremes.

So, if the heavy work of the orchard amounts to much, it needs a tractor which is substantial even if it must run slowly. Remember that a big horse *can* be used on a slow trip to town, and will pull either a heavy load or a light one, but the small speedy horse, under no conditions, can move the heavy load.

The gas tractor is more economical to operate in small sizes than the steam tractor. By reason of the difference in chemical composition of its fuel it is not apt to injure the trees. The combustion of gasolene or kerosene produces mainly carbonic gas and water. The

former the trees breathe in through their leaves, and the latter goes to form part of the great amount that trees take up through their roots. By Nature's wonderful processes these same products are made over into sap, sugar, and the very structure of the tree itself.

But, by reason of the sulphur contained in coal, the combustion products of a steam-engine have a blighting effect upon foliage. One has only to look at the stunted vegetation around coal mines in Missouri to realize this fact. Also the gas tractor takes less labor and is always ready for work without a siege of getting up steam; so all in all it is better adapted for orchard work.

The mechanical motor gives abundant power when it is needed, without continuing the expense of up-keep all the year round, as with horses. That means that power can be had for the deeper cultivation essential to a great moisture reservoir, and the fruit tree needs the most water at the very driest season of the year. It means quicker cultivation, hence better weed control. It means plenty of power for plowing under winter cover crops, crops which prevent the loss of plant food, and put it in a form where it will readily decay and become available. It means putting this vegetable matter deep beneath the surface where it will add to the moisture-holding capacity of the soil. Mechanical power means better control of conditions that formerly were largely up to Nature.

CHAPTER XV

RAISING WHEAT WITH A BIG TRACTOR

IT is a great problem for many men, and especially new ones in the field, to size up the equipment for traction farming. Many companies and partnerships are being formed to carry on wheat raising on a large scale by means of mechanical power. While no two of these are alike, some general data on the subject of equipment and capacity may be useful.

The entire work of raising, harvesting, and marketing the wheat crop in the Northwest must usually be done in one hundred days of actual work or less. It is generally reckoned that, counting out Sundays, holidays, and delays of all sorts, about two days out of three may actually be spent at work.

With the tractor it is, of course, possible to put in a longer day in the field than with horses, hence a tractor will take care of more acres than the number of horses which will develop the same amount of power during working hours. Since there are no chores before daylight or after dark, a full day of twelve hours in the field is easily possible. This may be increased to four-

teen or sixteen hours by working two shifts, and, if desirable, to twenty or even twenty-four hours. In the following figures, therefore, a working day of twelve hours is assumed.

Except for a very few small tractors which do not represent the type used in the Northwest, the tractors are usually of the low-speed type. In plowing, breaking or harvesting the various turns, delays, etc., will probably cut the average down to 1.8 miles of net working travel. In stubble plowing and discing at the same time, the extra length of turns will reduce this a trifle more; and where discing, drilling, and harrowing are done in combination, the time required to turn with such an outfit, plus the extra time required to all the seeder boxes, may reduce net working travel to 1.6 miles per hour. In straight hauling the full speed of 2 miles per hour and possibly a trifle better could be maintained. This would give 24 miles of haul in 12 hours; 21.6 miles in breaking, plowing, and discing, or harvesting; and 19.2 miles for discing, drilling, and harrowing together. These figures assume, of course, fairly level ground of ordinary stiffness.

A gas tractor actually developing 30-drawbar horsepower will pull eight 14-inch bottoms in practically any kind of sod, and frequently 10-bottoms. Figuring conservatively on eight bottoms, we can arrive at the daily acreage by multiplying together the number of

Breaking "twenty-year-old" alfalfa sod with a gas tractor

A 30-h.p. gas tractor threshing 3000 bushels of wheat per day

A 25-h.p. tractor discing, seeding and harrowing 50 acres per day

miles of working travel, and dividing by 99, which represents the width of the strip in inches required for turning an acre every mile. For example:

$$8 \times 14 \times 21.6 = 24.4 \text{ acres.}$$

Fifty days of breaking at this rate would take care of 1,200 acres which is about what a tractor of this size will handle with good management.

In preparing firm sod ground, it would be possible to use a battery of six 8-foot discs in a double line, followed by three 8-foot drills and five sections of ordinary drag harrow, without seriously overtaxing the tractor. Without the harrows it should be an easy matter. This outfit, covering a strip 24 feet wide, would handle over 55 acres a day and consume 24 working days in putting in the crop. Ordinarily, however, better results will be secured by first partially preparing the seed-bed, and then seeding at a more rapid rate. This is usually done on old ground.

The pulling of ten stubble bottoms at the average depth of five or six inches, would ordinarily be much less severe than pulling eight bottoms at a shallower depth in sod. The addition of a pair of disc harrows to loosen up the surface immediately will conserve moisture and make up a full load for the tractor. This outfit, covering a strip nearly 12 feet wide, will plow and disc 30 acres a day.

After the ground is once disced it is somewhat harder for the engine to travel, but a 30-horse-power tractor should be able to handle five discs and five drills, covering a strip 40 feet wide, and seeding 90 acres per day.

By the use of improved binder hitches it is possible to get a fortnight more work out of the tractor, which will easily handle five 8-foot binders and cover something like 100 acres in a day of twelve hours.

The same tractor that raises the crop can be used to drive a 40 × 60 separator and knock out 2,000 bushels or more of grain a day. At this rate, 12 working days would be required to thresh the crop.

A wagon and grain tank suitable for use in an engine train will weigh about 1,500 pounds and hold 125 bushels of wheat, weighing 7,500 pounds. On fair, level dirt roads the tractor will handle eight such wagons and take two carloads of wheat to the railroad at one trip. Assuming a yield of 20 bushels to the acre, it would require 24 trips to market the wheat.

If we assume that we are working with 1,200 acres of old ground then the tractor would be in use for the various operations the following number of days:

Plowing and discing	40
Discing and drilling	14
Harvesting	12
Threshing	12
Hauling	24
Total	102

It will be noted that over sixty per cent. of the time required to raise and harvest the crop is spent at the plow; and, of course, plowing requires more power while in progress than any other kind of work mentioned.

For marketing it is feasible and economical to use the big plowing tractor. It would seem at first glance as though the time required to market the crop might be cut down by the use of a tractor running at higher speed. A moment's consideration will raise a doubt as to this.

The United States Bureau of Agriculture Statistics, Bulletin 49, gives the cost of hauling crops from farms to shipping points. A mean of averages from Minnesota and the two Dakotas indicates that the average haul is 10.5 miles to the shipping point, requiring .77 day for the round trip. The average load is 54.4 bushels and the cost 5.6 cents per bushel with horses.

For faster road work tractors are built lighter and speedier than the heavy-duty plowing types. One of these small tractors running at 2.5 miles per hour, would complete the round trip in 8.4 hours, running at full speed both ways. If it ran at its low speed of 1.9 to 2 miles per hour under load and returned on the high gear it would still require 9.7 hours. No one who has ever ridden a tractor over the ordinary road at 2.5 miles an hour, will want to come home any faster unless the tractor is spring mounted.

On the low speed a 15-horse-power engine would pull four wagons containing 500 bushels, and on the high speed three wagons containing 375 bushels. The 30-horse-power tractor with the same crew would spend about 10.5 hours on the road. Neither machine would have time to make a second trip during the day, owing to the time required to load and unload. It would be far cheaper to pay the men a trifle more, for the extra time goes slow in pulling heavy loads. It will cost less per bushel to deliver the wheat, and the slower speed will be much easier on the engine and driver than the jolting at even a twenty-five per cent. increase in the rate of travel.

COST OF MARKETING

Figures will illustrate the difference. The cost per day with the 15-horse-power tractor would be as follows:

Two men and board	$6.50
Kerosene or distillate (at 9 cents)	2.70
Lubricating oil, etc.	.50
Interest, repairs, and depreciation	3.75
Use of four wagons	.50
Total	$13.95

If the tractor ran on the low speed under load and hauled 500 bushels the cost would be 2.8 cents a bushel. If it ran at a high speed, both ways, and pulled only 375 bushels, the cost would be 3.7 cents. The following are the costs with the 30-horse-power tractor, assuming that the men will be paid extra for the additional time:

Labor	$7.50
Kerosene or distillate	6.30
Lubricating oil	1.00
Interest, repairs, and depreciation	6.00
Eight wagons	1.00
Total	$21.80

The total load is 1,000 bushels and the cost less than 2.2 cents per bushel. It may seem unfair to compare the large engine with the small one; but only the smaller and lighter tractors have so far been operated successfully at speeds much in excess of two miles per hour. It might be possible to dispense with one man in hauling with a further slight saving, but the loss of time and greater liability of accident through having no one to watch the load, might easily offset any advantage thus gained.

COST OF EQUIPMENT

The prices of equipment vary so much that the following cost is only approximate:

30-horse-power kerosene tractor	$2,750
10-bottom plow	850
Separator	1,200
Disc harrows, each	35
Grain drills, each	75
Steel harrows (5 feet) each	6
Wagons	80
Binders (each)	140
Binder hitches (each)	35
Straw racks (each)	20
Total	$5,191

Equipment for various other work is purposely omitted, as well as some small items which are found on many grain farms. It is profitable to give the tractor a full load rather than try to economize on equipment. This, of course, does not mean to overload it.

In selecting the equipment one must figure on the number of acres to be handled, the capacity of the outfit, and the length of time available for doing work. The variation in practise is considerable, owing to the fact that traction farming in the majority of sections is comparatively new, and standard methods have not been worked out. Much depends upon the ingenuity and executive ability of the man who buys the outfit, His time for the first season will doubtless be so fully taken up with the breaking of the land that he will have sufficient opportunity to study the methods of the men around him. Many could well afford to wait until arriving on the ground before selecting any except the equipment they will be sure to need first, i.e., the tractor and plows.

CHAPTER XVI

TRACTORS AND DRY-FARMING

SIX hundred million tons of soil to the half-section lie in the surface foot of earth which is the workshop of the intelligent farmer. Other implements may stir this mass to productiveness, other machines and vehicles pass over it to take off the golden yield, but the work of the plow, which at least once in two years must turn this enormous weight bottom side up, is the mightiest labor of all.

In dry-farming sections it is hardly necessary to emphasize the vital importance, not only of proper plowing, but also of proper after tillage. Farmers are agreed that they should plow deep; that they must plow rapidly when conditions are ripe; that they must pulverize the ground thoroughly; that they must again bring the soil particles into close but not cemented contact; that they must preserve a loose mulch after plowing, after seeding, after harvest, after every rain. They also know the value of rapid seeding and harvesting; and they all appreciate the satisfaction of quickly turning the threshed crop into cash.

The only question then, is: How shall this be done?

In the answer, even more prominent than the plow is the matter of *power*. Power shapes our modern world, and nowhere is the solution of the power problem more important than upon the farms of our vast dry-farming area.

The stationary engine aids or replaces the dry-farmer's own muscle. The tractor comes to assist the animal as well as man. It satisfies emergency requirements. It withstands heat, flies, dust, blinding sun, and heavy continuous service when every possible bit of energy must be put forth to save moisture.

It reduces the hours of human labor for a given volume of output. It eliminates much of the enormous yearly labor of attendance. It calls for cheaper shelter for itself and fuel, and needs only a tenth of the building space required by horses of equal power, and their feed.

It requires no great variety of diet, and uses nothing that could be converted into human food. In the average case it is cheaper to buy and to operate than animals, more useful in times of pressing need, and infinitely simpler to maintain when not in use.

Yet for the present we must use the tractor *and* the animal. Which shall be used in greater strength must depend on the requirements of the farm in question. Capacity is all-important at many critical stages in dry-farming, and the tractor's endurance then outweighs all other considerations.

An Oregon outfit taking two carloads of wheat to the warehouse at one time

The number of work animals now kept is the practical minimum that can possibly plow, sow, and reap in season. Plowing already consumes sixty per cent. of the power required to raise and harvest the wheat crop. Deeper plowing is urged. Increase the horse-flesh for that purpose, and presently you have still a larger number of idle mouths to feed, and more team-poor farmers. Keeping broodmares for emergency work and selling their offspring to pay the cost of up-keep is an expedient possible only to a certain percentage of farmers.

Nor should it be necessary for all sections to conform to a type of farming that will employ to full capacity during all seasons the number of animals now needed for plowing. With the traction engine to take care of the heavy, rush work and look after itself the rest of the time, and with the number of horses determined by the odd jobs that need attention the year round, the power problem is permanently solved, and the type of farming can be chosen properly, i.e., with reference to markets, soil, and climatic conditions.

The horse reproduces, repairs, and regulates itself. It is understood almost by instinct. It is more reliable than a machine, more flexible in power, and adaptable to a much wider variety of uses. Yet we cannot depend on animal power alone to carry out the universal deeper plowing and more thorough tillage which is the creed of dry-farming.

Animal reproduction is too slow and inflexible to cope with swiftly changing conditions. It takes four or five years to make a good work horse. A modern factory can turn out a 30-horse-power tractor every hour. It takes many generations to change the type of animal, but only a few weeks to adapt a machine to a new condition.

Conceding the final triumph of mechanical power, we now come to a practical question as to its present status. From the dry-farmer's standpoint the steam tractor may well be omitted from the discussion. Labor and fuel costs, scarcity and hardness of water, enormous weight and wastefulness of time all argue against it.

Not that steam is dead; its days are not even numbered; three of the leading steam tractor builders report larger sales of steam tractors this year than ever before. But dry-farmers are buying gas tractors freely, who never were interested in steam; and these sales are increasing many fold each year without at all checking the development of older forms of power.

Each new thing comes as an *addition to our resources* rather than as a complete revolution. Man, animal, and steam power will perhaps show no remarkable decrease, but the dominant type of power on our dry-farms of the future will be gas power, and it is the efficiency of the gas tractor that concerns us most now.

CHAPTER XVII

THE FUTURE OF THE TRACTOR

IT is easy to remember the first gas tractor. Men still live whose lives have spanned half the history of the steam tractor. But the present type of the horse, except for minor details, has so long been fixed that its date is only a hazy guess.

Tractors, however, have improved astoundingly in five years, even in three years. One designer remarked in 1912 that a certain competing gas tractor had been improved sixty per cent. over the 1911 model; yet the older model was by no means the poorest of its kind on the market.

Three years ago there were eight, possibly ten, gas tractor firms in this country. Eight years ago there were only two. Now there are around fifty, building an average of two types or sizes each. Rivalry is standardizing and improving the output with wonderful rapidity. A three-year-old impression of the gas tractor's efficiency is obsolete. True, there is wide difference in the merit of various makes, but the majority are so perfected that responsibility for success is passing swiftly from the maker to the operator.

Two engines made the same day from the same patterns and the same batch of materials, machined, assembled, tested, and inspected by the same crews, and shipped to the same community, will often form the basis of widely differing reports. The great bulk of operators of a given engine are satisfied; the rest are not. When the crop fails, do you blame the farm or the farmer? When the engine fails, do you say that the engine won't run, or that the tractioneer can't run it?

It took the first successful builder of a gas tractor five years to convince three hundred farmers of its value. But in 1912, 15,000 new buyers were convinced that some make of gas tractor was practicable. The doubling of that number in 1913 will come about largely through the experience of purchasers in 1912 and before. The success of any enterprise depends as much upon the management as the equipment.

The gas tractor is here. Its lasting popularity is assured. Already it is made in a variety of types that seemingly should fit every need. Yet we all see opportunities of improvement. No one design can embody all the desirable features, nor fit every condition. Each designer must start with a conception of what is most important, and work toward that end.

Practical men, students, and molders of public opinion in all walks of life, can render agriculture a great service by studying deeply this question of motive power, and

laying bare the essential points on which engineering and agriculture must get together. If mechanical power is more efficient than animal power, even for only part of the whole number of tasks, then no greater good can be done than to encourage its development along right lines.

Close contact of all concerned with the makers of the gas tractor and with all makers of farm machinery will mold design in the direction of greatest usefulness to the public. A knowledge of agricultural and economic conditions, dovetailed with the engineer's faculty for devising ways to meet new needs, will solve present problems in the quickest way.

The public's permanent interest in power and plowing is not a matter of whether one make of tractor is better than another, or whether one or two or four is the ideal number of cylinders. The question of steam or gasolene or kerosene is not of everlasting importance; nor are the relative merits of tractor, cable-plow, and auto-pulverizer. These are all vital for the moment, but in the end everything comes back to the question whether animal or mechanical power shall predominate. It will be settled on the basis of efficiency. The animal holds out little hope of improvement; the mechanical motor every prospect of wonderful advances. You, as a reader, may, if you will, play an important part in determining its ultimate character.

The faith of the manufacturer in the tractor's future is expressed in his great shops with their piles of raw material. The activity of his plant is evidenced by the lines of loaded flat cars ready for shipment. The efficiency of his product is shown in long, smooth lines of conquered prairie. Finally, the verdict of the farmer is suggested by the enthusiasm with which the long trainloads are met at the distributing points thousands of miles from the factory.

In the busy shops the engineer, the draftsman, and the grimy machinist in his overalls are working together to solve the problems of power and plowing. They are helping almost as much to assure our daily loaf as the farmer who uses the tractor to bring a harvest out of the dull earth.

Let there be, then, a spirit of co-operation between factory and farm. Let the agriculturist or the public man who wishes improved tractor equipment begin with a helpful suggestion and reserve condemnation until after other devices have failed. On the other hand, let him also call upon the factory's sources of information in choosing equipment or operating it with the highest degree of efficiency.

The manufacturer has done much to conserve human effort. It is a far cry from the days of "The Spaders" to the spectacle of three powerful gas tractors hitched to one giant plow of fifty bottoms — plowing an acre

in four and a quarter minutes — the world's absolute climax in the use of mechanical power on the farm.

But not all the problems are up to the designer and the builders. They are limited by problems of fuel supply and finance over which they have no control.

The crude oils of today yield only a little precious gasolene as compared to the light oil market that Drake's discovery opened. We have seen gasolene, a by-product, go higher and higher in price, while kerosene, formerly the main commercial element of petroleum, has become a by-product of lower and lower value. Refiners will no longer supply crude oil in unlimited quantities for use in steam boilers and have notified users of fuel oils that they must curtail their needs.

The great family of kerosenes and similar distillates, however, are stored in enormous quantities, and offer a universally distributed supply of cheap fuel for internal-combustion engines. Railways and central power plants that are using oil wastefully under steam boilers must find better ways to conserve heat units, so the era of the gas engine is at hand.

The farmer will benefit through the accumulated knowledge of engineers who are applying the gas engine to every form of power need. Today he uses more gas-engine horse-power than all other industries combined. The gas-engine sales to the farm have climbed in less than fifteen years from almost nothing to a greater

volume than that of the harvester, three generations old. But even so, only one acre in ten thousand is as yet plowed by mechanical power.

In order to secure the full benefits capital must come to the aid of the farmer. National legislation, creating a system of long-term agricultural credits, will enable the farmer to substitute for wages interest payments on machines, at a greater profit to himself and a lower cost of production. The country banker cannot finance the coming of mechanical power to the farm out of his current deposit funds.

Co-operation in financing and co-operation in farming will have much to do with the future of the tractor; and the success of the tractor and of future farming are inseparably linked together. Labor is needed in our factories to put value into our raw materials. Machinery must take its place on the farm.

But the farmer alone cannot solve the problem of increasing the producing power of the farm. Engineers, manufacturers, men trained in scientific agriculture, and finally the financier, all must help.